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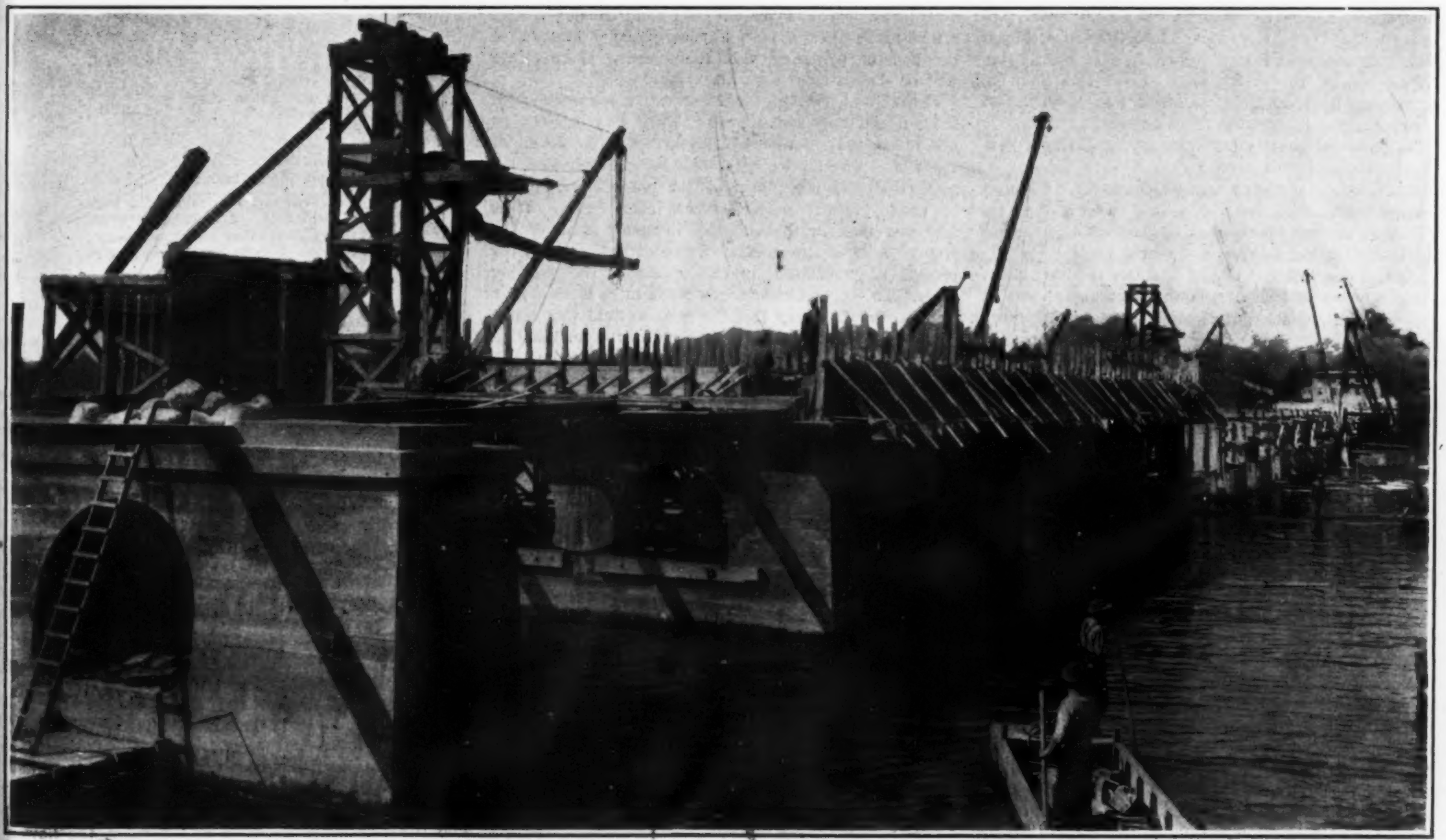
One of the old wooden trestles that have been replaced by a substantial masonry structure.



Some of the reinforced concrete piers of the new viaduct.

REINFORCED CONCRETE VIADUCTS BUILT BY THE PENNSYLVANIA RAILROAD COMPANY OVER INLETS OF CHESAPEAKE BAY ON ITS PHILADELPHIA AND WASHINGTON DIVISION.—[See page 24.]

Experiments in Hybridizing Japanese Flowers

Which Appear to Show a Variation in Mendel's Law

By Walter Proctor Jenny, Ph.D.

The results of these experiments in hybridization are due to the discovery made early in the progress of the work, *that the dry pollen of the white moonflower, applied to the stigma of the morning glory, is inert and will not fertilize the ovary, unless the pollen be wet with the dew-like fluid excreted upon the surface of the stigma of the moonflower.*

The purpose of this article is to place upon record the results of experiments conducted for a term of years, at private expense, at my home in the city of Washington, D. C., an investigation undertaken and carried out owing to my interest in plant breeding—an interest stimulated by the fascination that attends the creation of new and beautiful flowers.

The method followed departs so widely from the usual procedure in hybridizing, and the results obtained are so exceptional, and offer such broad as well as important possibilities in the creation of new types, that they can scarcely fail to prove of interest to other workers in this field.

That the natural stigmal fluid of the moonflower, namely, the dew-like excretion deposited upon the surface of the stigma, when in readiness for self-fertilization, is also essential to the development of its pollen in the fertilization of the ovary of the morning glory, was discovered in this way. In my first attempts, I removed the anthers from the flowers of the morning glory, and then applied the pollen of the moonflower, using the reflexed flower as a brush. Some twenty-five flowers were thus pollenated, but only one produced seed. In the following season, 1912, I pollenated nearly 200 flowers of the morning glory, applying the pollen of the moonflower in different ways, without obtaining seed in a single instance; this was before I found that the stigmal fluid of the moonflower was needed in order that fertilization of the ovary might take place. In attempting to reverse the process and pollenate the moonflower with the pollen of the morning glory, I noticed the way in which the pollen grains adhered to the moist stigma of the moonflower, and with only the thought to make the pollen adhere more perfectly, I tried the experiment of transferring this excretion of the stigma to the stigma of the morning glory before applying the pollen of the moonflower. Several flowers of the morning glory were depollenated, and the stigmal fluid, together with the pollen of the moonflower, applied. A few days later, on examining these hybridized flowers, it was seen that fully one half of the flowers had commenced to develop seed. From this time on, the stigmal fluid of the moonflower was employed in all experiments in crossing these flowers.

The flowers experimented with are of different genera of *Convolvulaceæ*, namely,

1. "The early blooming white moonflower," *Calonyction speciosum*, with black seed, said to be a cross between *C. Mexicana alba* and *C. grandiflora alba*; it has been in cultivation a number of years; and

2. Numerous varieties of the Japanese morning glory, *Ipomoea Chinaensis*, having flowers in many shades of red, rose, lilac, violet, purple, and blue, and also pure white.

Natural hybrids of the white moonflower and the morning glory do not appear to take place. I have, however, observed that the Japanese morning glory and the American morning glory will occasionally cross, where growing near to one another.

The flowers were grown in 12 to 14-inch pots, in the open air; the veins being trained upon trellises of bamboo and wire.

In the following statement, no attempt is made to give particular instructions to be followed, but rather to set forth what was done to produce the hybrid ipomoea I have named *Banzai*.

All hybridizations that produced seed were made with the white moonflower as the male parent and the Japanese morning glory as the female. A number of attempts were made to reverse the process, applying the pollen of the morning glory to the stigma of the moonflower; but all failed to set seed. All hybrids and cross-bred plants described produced fertile seed.

The morning glory blooms in the early morning, often before daylight, while the moonflower blooms soon after sunset; so that to obtain a supply of moonflowers for hybridizing, it is usually necessary to gather the flowers soon after they open, and before they have been visited by insects, and to preserve them in shallow dishes of water in an ice chest. Where no insects are present the moonflowers may be let to remain on the vine and to be picked at early dawn, at the time the hybridization is performed. In my experiments no risks of insect interference have been allowed.

The flower selected for the female parent has first its pollen removed by the application of a fine stream of water—the excess of water is drained out and the flower dried by gently applying slender slips of blotting paper (following the method published by Mr. George Oliver, Department of Agriculture, Washington, D. C.).

I perform the hybridization as follows: I take a moonflower, reflex the flower and pull off the stamens, leaving the stigma intact. The stigma of the moonflower is then applied to the stigma of the morning glory, gently rubbing them one upon the other, so as to transfer the dew-like moisture upon the moonflower stigma to the stigma of the morning glory. This is repeated two or three times, using a fresh moonflower for each application. Then select a moonflower with ripe pollen, reflex the flower and holding it so that the stamens are loosely bunched together, insert the stamens in the tube of the morning glory, with the stigma of the morning glory in the midst of the anthers—that is, the stigma of the morning glory is surrounded on all sides by the anthers of the moonflower; a slight movement, in and out of the stamens, at the same time rotating the moonflower, transfers the pollen to the wet stigma of the morning glory, to which it adheres. This application of pollen is repeated with one or more fresh moonflowers. The flower is then closed (like an unopened bud) and tied at the tip with yarn, to exclude insects—about 40 per cent of the flowers thus hybridized produce seed.

Sometimes I vary this method by first wetting the stigma of the morning glory with the vitalizing fluid of the moonflower and then alternately applying the anthers and the stigma of the moonflower, gently rubbing in the pollen with successive applications of the stigmas of fresh moonflowers, until the stigma of the morning glory is loaded with the adhesive coating of pollen.

The first hybrid that I obtained was Banzai, a flower of rare beauty, with a deep carmine center, margined by pure white. It was at once recognized as constituting a new type; of vigorous growth, and what was most important, the flowers had good keeping quality and did not wilt or change color, if shielded from the sun, even in the heat of summer. The great drawback with all morning glories, both Japanese and American, is the lack of permanence in the flowers, which either wilt or change color soon after sunrise.

Banzai was produced as follows: In the summer of 1911, a red Japanese morning glory was selected as the female parent and hybridized with the pollen of the white moonflower, as follows: the flower was depollenated and the pollen of the moonflower applied by employing the reflexed flower as a brush. It is supposed that in this solitary instance, some of the stigmal fluid of the moonflower was transferred in the process of pollenation to the stigma of the morning glory. This hybridization was made more than a year prior to the discovery that the stigmal fluid was essential to the development of the pollen in the fertilization of the ovary. As stated, only a single flower thus pollenated produced seed. In 1912 this seed was planted in a flower pot (12 inches in diameter) and early in July the new hybrid bloomed, and its self-pollenated seed was saved. A few flowers of Banzai, as an experiment, were again crossed with the pollen of the white moonflower; the procedure, employing the stigmal fluid, as described, was varied in that the pollen of the Banzai flowers was not removed. Several flowers, thus at once self-pollenated and reinforced with the pollen of the moonflower, produced seed.

In 1913 these two lots of seed were planted under like conditions; but from germination to maturity, the plants that were twice crossed with the moonflower were the most vigorous in growth and their flowers were more nearly true to type. For this reason, these plants that had been reinforced by inbreeding with the moonflower were selected to carry on the strain and marked Banzai No. 2.

The diagram attached hereto shows graphically the several steps followed in the seasons of 1911, '12, '13, and '14, in originating and in fixing true to type the hybrid morning glory Banzai.

The self-pollenated seed of Banzai, No. 1, produced eight plants in the second generation (1913), that were carefully watched during growth. None of these seedlings appeared to conform to Mendel's law, in resembling the male parent, more than did the original hybrid Banzai, No. 1, the female parent continuing dominant. There was, however, a noticeable decrease in the vigor of growth, compared with Banzai, No. 1, notwithstanding that the soil was rich and growth stimulated by watering with liquid fertilizers. The flowers were also somewhat smaller in size, and a tendency was observed to eliminate the white border.

About this time, the results of other experiments with these flowers indicated that this reinforcement of a hybrid, by inbreeding with its male parent, might be improved upon, by first depollenating the hybrid flower and treating the stigma with the developing fluid of the moonflower, as described, then applying the pollen of a number of flowers of the same hybrid, and finally rubbing in the pollen of the hybrid, using to do this both the anthers and stigma of two, or often three, moonflowers, thus in one operation fertilizing the hybrid flower with the pollen of flowers from the same plant, or preferably, with the pollen of selected flowers from another plant of the same hybrid, and blending therewith not only the vitalizing fluid of the stigma of the moonflower, but the pollen of the moonflower as well.

This method of dual fertilization was employed in the season of 1913 in the endeavor to fix Banzai No. 2 true to type, with the result that fully 50 per cent of the flowers so treated produced seed.

Diagram of the multiple hybridizing of a Japanese morning glory with the pollen of the white moonflower in producing the original hybrid and in the successive repollenations whereby the hybrid flower is made to reproduce itself true from seed, and has imparted to it an increased vigor of growth.

Season of 1911.

Male Parent.
White Moonflower.

Female Parent.
Red Japanese Morning Glory.

Depollenated and the pollen of the moonflower applied, by employing the reflexed flower as a brush.

It is supposed that in this instance some of the stigmal fluid of the moonflower was transferred in the process of pollenation to the stigma of the morning glory.

Season of 1912.

Original Hybrid.
Banzai, No. 1.
First Generation.

Pollen not removed. Stigma treated with stigmal fluid. Finally repollenated with pollen of the moonflower.

Season of 1913.

Banzai, No. 2.
Second, First Generation.

Depollenated. Stigma treated with stigmal fluid. Pollenated with the pollen from other plants of Banzai, No. 2. Finally repollenated with pollen of the moonflower.

Season of 1914.

Banzai, No. 3.
Third, First Generation.

These seed, planted in 1914, produced Banzai, No. 3, the result of twice inbreeding the original hybrid with itself and with its male parent—in fact, Banzai No. 3 may be looked upon as *the third, first generation, of the original hybrid.* That no true second generation, or second year's growth, took place, counting from the year that the hybridization was performed, is of interest in its possible relation to the operation of Mendel's law.

The successive pollenations of the original hybrid with the moonflower caused a notable increase in vigor of growth, the leaves becoming broader and the white border of the flowers more prominent—in fact, the cumulative effect was to accentuate those qualities that appear to have been derived from the moonflower.

In Banzai, as thus developed and fixed, the female parent is dominant; it has inherited from the moonflower vigor of growth and increased substance in the flowers—the flowers are also marked by a white border; in all else, Banzai seems to inherit from the morning glory. Owing to the greater substance of the flowers and the marked permanence of the color, the flowers keep well; in this respect Banzai is superior to either parent. If picked early in the morning, the flowers may be kept in an ice-chest (at a temperature of about 55 deg. Fahr.) for 24 hours. On cloudy days, the flowers of Banzai remain on the vines without closing until

after sunset. The buds are long and large, and the flowers as they naturally open measure 3 to 4¼ inches across. The largest flowers I have raised measured 4⅝ inches across, without touching the flower in any way to enlarge it.

Banzai may truly be termed the first of a new type of morning glory. It is strong and vigorous in growth, the vines attaining with five months' growth from seed a height of 25 to 35 feet. The leaves are 5 to 8 inches long, shaped like an aeroplane, often with two pairs of wings in the same plane, situate near the axil of the leaf. The flowers are borne profusely, and have a brilliant carmine center with a margin of pure white one fourth of an inch broad. The color appears to be due to a dye filling the cells of the flowers; it is extracted by macerating the flowers in alcohol. The solution is of a clear carmine color, and reacts with acids and alkalies like litmus—changing to blue with alkalies and red with acids.

The method here set forth was tested in the season of 1913, with other varieties of the Japanese morning glory. In 1914 the seed of these hybridizations was planted, producing a number of new flowers of the Banzai type. It was noted that various shades of lavender, rose, blue, and purple, yielded when hybridized with the white moonflower new varieties, having the center of the color of the female parent, with a border of pure white, in this resembling Banzai. It is suggested that these new hybrids, in which the female parent is so uniformly dominant, constitute a new type, distinguished from normal hybrids in that the male parent has exerted only an influence upon the resultant hybrids. Should this view be confirmed by further study, they might be designated as *influence hybrids*. Other experiments, in which the morning glory was subjected to dual pollenation, the pollen of a different variety of morning glory being mingled with the pollen and stigmal fluid of the moonflower, resulted in many new and surprising hybrids; some with new colors, widely variant from the flowers from which they had been derived. Some of these new hybrids will be preserved and further cultivated to observe the results in future generations.

In conclusion: hybrids of the Japanese morning glory with the white moonflower seem not to be subject to the operation of Mendel's law or are only subject to it in a limited way; this may be owing to:

1. That for some reason, the white moonflower is immune from the influence causing the seedlings of hybrid plants to vary in the second year. In this connection it is worthy of note, that crosses of the Japanese and American morning glory, arising from pollenation by insects, follow Mendel's law.

2. That this exemption is due to some quality or property of the fluid excreted by the stigma of the moonflower.

Owing to the fact that it has not been found possible to hybridize the morning glory without employing the stigma fluid we cannot, with the information at hand, differentiate 1 and 2 so as to determine whether the exemption may be due to one or to the other, or to both combined. The cause of this apparent immunity remains to be determined by experiment.

In the successive repollenations of the original hybrid Banzai, No. 1, no true second generation has occurred; but only a series of progressive first generations; arbitrarily enforced, my working theory, in carrying out these experiments, having been that the type might be fixed and at the same time the vigor of growth increased, by judicious inbreeding as described.

The action of the excretion of the stigma of the moonflower in developing the growth of the pollen should be studied under the microscope. It may be found on further investigation that this stigmal fluid is generic in its action, and that it will also develop the pollen of other genera of plants, so that its possible employment generally in experiments in hybridizing is suggested. Also this work upon the Convolvulaceæ may lead to the search for similar stigma fluids in other monopetalous plants, particularly where hybrids do not occur in the ordinary course of nature.

The X-Ray Spectrometer*

A New Instrument for the Study of the Properties of Crystals

It is now well known that a homogeneous pencil of X-rays is capable of reflection by a crystal provided that the rays are directed upon the crystal at the proper angle.[1] If λ is the wave-length of the X-rays, d the spacing of the crystal planes, and θ the angle which the rays make with the planes, these quantities are connected by the relation $n\lambda = 2d\sin\theta$ [2], where n is an integer.

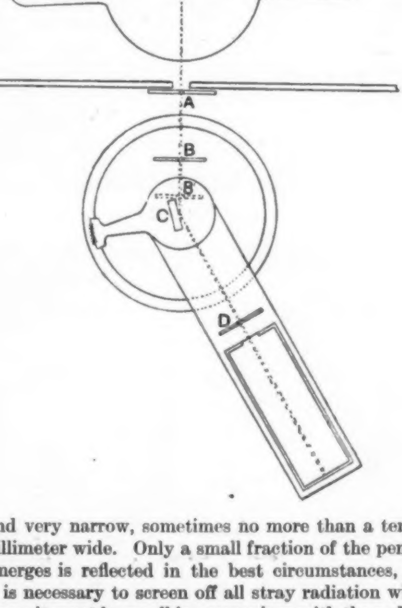
The object of the spectrometer is to determine the value of θ in any given case—that is to say, for a definite set of X-rays and a definite set of crystal planes. The results may be classified as follows: If we use different crystals or different faces of the same crystal, but keep the rays the same, we can compare the spacings of the various sets of planes. In this way we arrive at a knowledge of the relative positions of the atoms in the crystal that is to say, we determine its structure.

If we use the same crystal always, but examine the angle of reflection of different homogeneous X-rays, whether from the same or from different sources, we have the means of comparing the wave-lengths of those rays. We can, in fact, analyze X-radiation in exactly the same way as an ordinary spectrometer analyzes light.

The new instrument resembles the ordinary spectrometer in its general construction. To the collimator corresponds a set of narrow slits limiting a pencil of X-rays, which is directed so as to pass through the axis of the instrument. A crystal takes the place of the diffraction grafting, and is mounted on a small revolving table. The crystal face or set of planes which is acting as reflector is made to contain the direction of the axis of the instrument, and the crystal is turned round the axis until the face makes the proper angle with the incident pencil. The reflected ray then enters a cylindrical ionization chamber filled with gas which it ionizes. The chamber takes the place of the ordinary telescope, and the measurement of the ionization current by an electroscope corresponds to observation by eye or by the photographic plate.

In the drawing,[3] which shows the arrangement of the apparatus in plan, Q is the antikathode of the X-ray bulb. The construction of the bulb is a little unusual in that the antikathode is placed perpendicularly to the kathode ray stream; the bulb can therefore be conveniently arranged so that the X-rays leave the antikathode at a grazing angle. The finer the angle which the rays make with the antikathode, the more nearly does the source become, effectively, a "bright" line; and the narrower the line the brighter it becomes, because the "whole illumination" given out in any direction by the spot on the antikathode is independent of the direction. The law followed is not that of the illumination by a surface of uniform luminosity, but rather that of the illumination due to a number of separate sources lying in one plane, each radiating uniformly in all directions. It corresponds to the case described by Rutherford, in which α rays are radiated from a uniform thin sheet of radio-active matter spread upon a plane surface (*Phil. Mag.*, August, 1906). The arrangement is of considerable value; the more nearly is the source a bright line parallel to the slit, the "purer" is the spectrum.

The X-ray bulb is inclosed in a wooden box heavily coated with lead. The object is to protect not merely the observer but also the sensitive apparatus. The slit through which the rays pass is only a few millimeters



long and very narrow, sometimes no more than a tenth of a millimeter wide. Only a small fraction of the pencil that emerges is reflected in the best circumstances, so that it is necessary to screen off all stray radiation with great care; it must be small in comparison with the radiation which is to be measured. Adjustable slits are placed at A where the rays leave the box, and again at B, the second slit being also capable of a movement which brings it close up to the crystal, as at B'. The crystal is shown at C, and a third slit, D, is placed just in front of the ionization chamber.

The ionization chamber is a cylindrical brass chamber 15 centimeters long, and is filled with some heavy gas, so that the ionization current may be as large as possible. Sulphur dioxide is convenient in many cases, but methyl bromide is much better for rays which can excite the bromine X-rays. Such rays are, for example, given off by antikathodes of silver, rhodium, or palladium, the latter two of which have been much used in the determination of crystal structure, because they give off intense homogeneous rays and also stand up well against the bombardment by the kathode stream. The chamber is insulated and maintained at a high potential, which drives any ionization on to an internal electrode. The latter is connected by a fine wire to the gold leaf electroscope (Wilson pattern) within the shield. The connection with the electroscope terminal is made at a point lying on the axis of the spectroscope, so that the ionization chamber and the connecting wire may revolve together about the spectrometer axis without straining the connection. The shielding is made solid and strong: it is necessary that the electrostatic screening should be perfect, and the electroscope must be protected from drafts which may cause changes in temperature.

The gold leaf is illuminated by reflection from a mirror, and viewed through a microscope. A strong X-ray reflection will cause the leaf to move twenty or thirty scale divisions in a second.

The angular positions of the crystal and the ionization chamber are read from the vernier shown. Observations can easily be made to half a minute of arc, and much finer work could certainly be done, if it were required. The actual angle of reflection can be measured with an accuracy higher than can be reached in our knowledge of certain other data used in some of the calculations; for example, the actual weights of the atoms.

Crystals are often very imperfect in construction, consisting rather of a conglomerate of smaller crystals in more or less imperfect alignment. It is interesting to observe that the spectrometer may be used in ways which almost completely overcome the evil effects of the imperfections. In the case of a very perfect crystal like the diamond, the slit at A is not used, but B is set very fine; D is wide open. The crystal is slowly turned by a tangential screw attached to the revolving table, and there is no reflection at all outside very narrow limits. The angle of maximum intensity of reflection can easily be determined to a few seconds of arc. But a crystal of rocksalt cannot be treated in this way. It is best to set A and D fairly fine and not to use B at all. On account of certain most fortunate geometrical considerations, a homogeneous pencil of some divergence issuing from A and reflected at various points on the crystal face is brought to a line focus at D, provided that A and D are at equal distances from the crystal (Proc. Roy. Soc., lxxxviii., p. 433). A perfect crystal would reflect such a pencil only along a certain vertical line on the crystal face; but a poor crystal, like rocksalt, at a number of separate points on the face. Even crystals which are scarcely recognizable as such may be treated by this method.

The higher order of spectra, that is to say, reflections at angles for which n has a large value, three, four, or five, naturally give more accurate values than lower orders, though the intensity diminishes rapidly as n increases. The "resolving power" increases even faster than n, since $d\theta/d\lambda$ is easily seen to be equal to $\tan\theta/\lambda$, which becomes very large as θ approaches the value $\pi/2$. For example, a certain pair of lines emitted by a platinum antikathode are separated by thirty minutes of arc in the first order spectrum reflected by the cleavage face of the diamond, but in the third order spectrum they are two and a half degrees apart.

With a little practice it is quite easy to pick up the reflected X-rays. While the search is being made the slits are opened wide; as soon as the reflection is observed the slits are made narrower, and accurate measurement is then possible. It is a comparatively simple matter to find the angles of reflection of rays of given quality in the various faces or sets of planes of a crystal. The greater difficulty arises in the geometrical interpretation of the results.

* Reproduced from *Nature*.

[1] A summary of the principles on which this experiment is based, and of the progress of its development may be found in *Nature* of July 9th, 1914, p. 404.

[2] See Proc. Camb. Phil. Soc., November 11th, 1912.

[3] From a book to be published by Messrs. G. Bell and Sons.

The Planet Jupiter*

Possible Explanations of Some of Its Phenomena

By Rev. Theodore E. R. Phillips, M.A., F.R.A.S.

THOUGH lacking in those special features which, in the popular view, invest Mars with such an atmosphere of romance, Jupiter, nevertheless, claims in an equal degree the close attention of telescopic observers. Indeed, to the amateur whose optical resources are usually of a modest nature, Jupiter affords a far more profitable field for work than Mars, whose small disk only now and again presents developments on a sufficiently large scale to be well within the grasp of small apertures. Such a development on Mars has occurred in recent years in the Nepenthes, L. Moeris, and Thoth region; but, broadly speaking, it may be said that, even in large instruments, the approximately stable features of the smaller and more condensed planet cannot, in the nature of things, present constant and unexpected changes, such as demand the watchful attention and assiduous work of the observer of Jupiter.

As regards physical condition, it has long been recognized that Jupiter has many points of analogy with the sun. Its density is the same, and it is generally inferred that, like the sun, it is in a heated and expanded condition, and that, if not still partially gaseous, it is, at any rate, in a viscous and semi-liquid state. Many features, too, of superficial resemblance have been pointed out by various investigators. To refer to two of the most striking and obvious instances, we may mention: (1) The analogy between the spot-zones on the sun and the belts of Jupiter; and (2) the equatorial acceleration of both bodies.

As regards the first of these, it has been suggested by Lau (*Astron. Nachrichten*, Band 195, No. 4673) that the reason Jupiter has belts instead of zones of spots is to be found in its rapid rotation. The material forced upward from the lower strata of the planet, bringing with it a smaller linear velocity than that of the surface, streams eastward and assumes the appearance of elongated streaks. If the centers of eruption are sufficiently numerous, belts are formed; and it is suggested that, were the sun's rotation much more rapid than it is, the solar surface at spot maximum would also present dark streaks or belts.

In accordance with this theory of belt formation it will be remembered that the great revival of Jupiter's north equatorial belt in 1912-1913 began with the outbreak of a few isolated dark spots, which quickly spread out round the planet.

As regards the second of the analogies above mentioned, it will be recalled that the rotation of the sun can be fairly represented by a simple empirical formula, the velocity being related to the latitude and diminishing from the equator toward the poles. Now Cassini, in 1690, found that a spot on the equator of Jupiter required about five minutes or so less for a rotation than an object in the southern hemisphere; and subsequent observations have established the existence of a rapid equatorial current as a permanent feature of the visible surface of the planet. It is true that the cases of Jupiter and the sun are not quite the same; on the former there is no general increase in the rotation period with increasing latitude, but a sudden and abrupt change in the velocity in both hemispheres at about latitude 7 degrees. The equatorial current of Jupiter is therefore like a mighty river sharply bounded by two banks which are usually indicated by the two great equatorial belts.[1] Beyond these the arrangement of the currents is unsymmetrical and dissimilar in the two hemispheres; but, notwithstanding these differences, the analogy between the equatorial accelerations of the sun and Jupiter is very striking, and it is hardly possible to doubt that the cause in each case is the same.

It is not intended in this article to discuss in any detail the physics of Jupiter, but the analogy, to which attention has been drawn, between the planet and the sun, suggests certain possible explanations of some of the planet's phenomena.

(*a*) It has been found that certain sunspots appear to be vortices, and exhibit a whirling motion. It is suggested that many of the Jovian spots are of the same nature, and are the results of disturbances whose origins lie at some depth below the superficial layers. Kritzinger (see *B. A. A. Journal*, volume xxiv, No. 9) thinks it probable that, in accordance with Emden's theory of the sunspot zones, a number of discontinuous surfaces are developed within the planet, and that the edges of these different surfaces at the boundary of the disk produce the belts. The effect of two terrestrial atmospheric layers of different density, with one gliding over the other, in producing clouds of the cirro-cumulus type is well known, and it is hinted that the Jovian spots have an analogous formation. Lau also (*Astron. Nachrichten*, Band 195, No. 4673) considers that vortices are formed along the line of contact between the great equatorial current and the slower moving material north and south.

It is now very generally held that the Great Red Spot is a vortex. That it is not a solid feature of the planet is proved by its extensive wanderings, but at least it is sub-permanent, and has indicated a center of disturbance which has existed certainly for over eighty years, as Denning and Kritzinger have independently shown, and probably for over two hundred and fifty years. The idea that the Red Spot is a vortex is well supported by the behavior of the dark material forming the South Tropical Disturbance, or "Schleier," which has been so prominent a feature of the disk during the last thirteen years. Six times has the Disturbance, which is situated in the same latitude as the Red Spot, overtaken the latter, and its behavior at such times, though still in some respects mysterious, is nevertheless instructive. Now it has been observed that, as the *p* end of the Disturbance approaches the *f* "shoulder" of the hollow, it becomes accelerated, but that after its appearance west of the *p* "shoulder" it is retarded. The same thing is true of the *f* end. This is strongly suggestive that the Red Spot is a center of attraction, a vortex which draws into itself the surrounding material. It is, however, not certain at what level the Disturbance moves. Lau considers that it passes under the white material overlying the Red Spot, and certainly little or no trace of it is seen during its passage across the bay. On the other hand, the outline of the Spot itself has sometimes been faintly discerned during conjunction, which suggests that the dark matter is mostly whirled round the periphery of the vortex and passes out on the *p* side. It has been observed that the time occupied in passing from the *f* to the *p* "shoulder" by the ends of the Disturbance is very decidedly shorter than the time usually required to move over the same distance elsewhere. The vortex theory also explains the formation of the bay, or hollow, in which the Red Spot lies; since the drawing in of matter toward the center at the lower levels must be accompanied by an outward flow at a greater altitude. This latter may very well drive back the material of the south equatorial belt, and consequently give rise to the formation of the well-known bay at its south edge.

(*b*) The equatorial acceleration of Jupiter, like that of the sun, presents an interesting problem. Lau, in his

* From *Knowledge*.

[1] The southern line of demarkation is usually between the two components of the south equatorial belt. In the northern hemisphere it is commonly at the north edge of the north equatorial belt, though when the belt is broad and double it often lies between the two components.

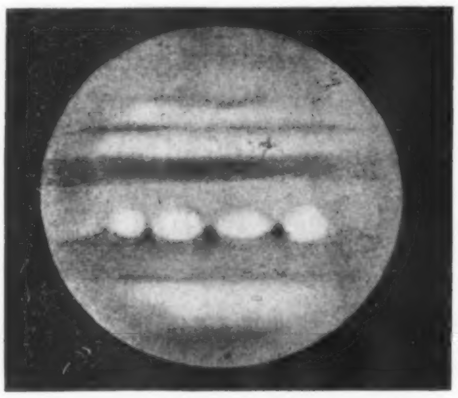


Fig. 1.—July 24th, 1913. $\lambda_1 = 55°$. $\lambda_2 = 82°$.

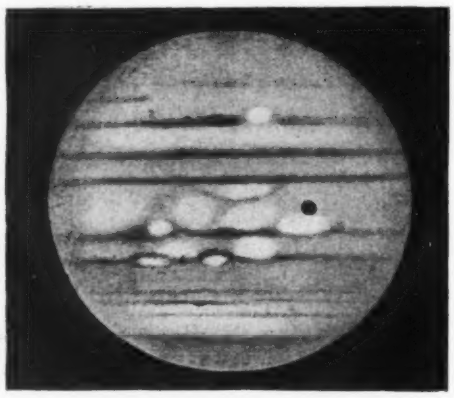


Fig. 4.—August 23rd, 1914. $\lambda_1 = 78°$. $\lambda_2 = 358°$.

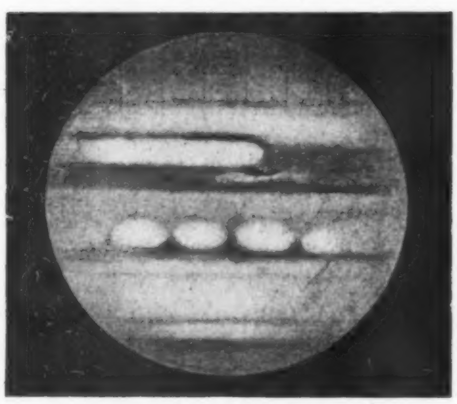


Fig. 2.—August 28th, 1913. $\lambda_1 = 60°$. $\lambda_2 = 181°$.

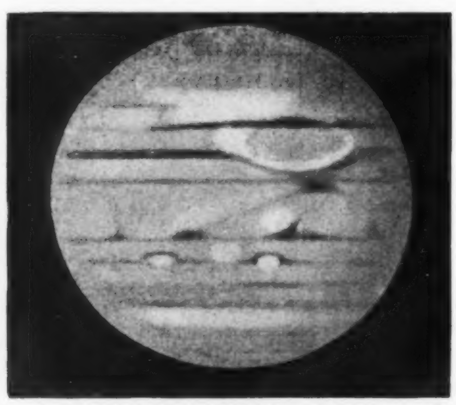


Fig. 5.—August 29th, 1914. $\lambda_1 = 336°$. $\lambda_2 = 184°$.

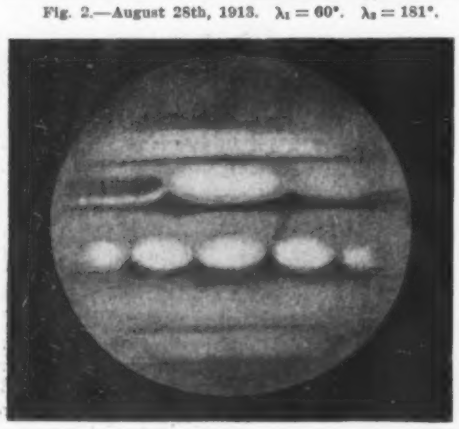


Fig. 3.—September 12th, 1913. $\lambda_1 = 252°$. $\lambda_2 = 259°$.

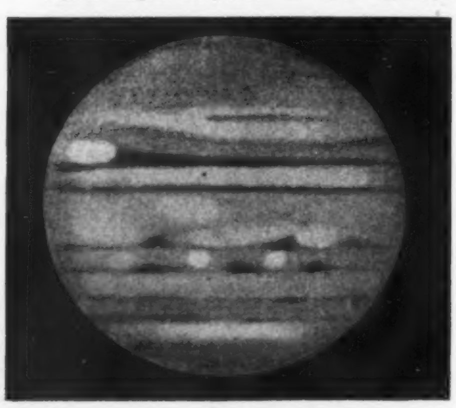


Fig. 6.—August 31st, 1914. $\lambda_1 = 270°$. $\lambda_2 = 103°$.

The planet Jupiter as seen in an inverting telescope.

article above referred to, speaks of it as a survival from an earlier condition of things, and apparently considers that it has its origin in the falling in of particles possessing a greater angular velocity than the planet itself. Whether the combined momentum of such particles would be sufficient now to produce an appreciable effect may be questioned; but, if the masses of the planets and the sun have been in the past much increased by the accretion of meteoric dust particles revolving in direct orbits, the tendency would certainly have been to produce an accelerated superficial equatorial motion. A simple calculation shows that particles revolving close to the sun's surface would perform a revolution in, roughly, three hours, whereas the sun itself requires for a rotation at least twenty-five days. For particles one hundred miles above the present surface of Jupiter, and spots on the Jovian equator, the corresponding times are 2 hours 57 minutes and 9 hours 50 minutes, respectively. The same kind of thing is true of Saturn; and it seems quite possible that we have here, at any rate, one factor in the production of the equatorial acceleration exhibited by the larger bodies of the solar system.

A point which has attracted the close attention of observers of Jupiter is the variation in the velocity of different parts of the disk. Separate and distinct currents in the surface material of the planet whose latitudinal limits show only small changes have for several years been recognized, but their rates of motion are found to be variable. The drift of spots differs slightly from year to year, and there is reason to suppose that in some instances the variations in velocity are of a periodic nature, with minor fluctuations superposed on longer waves of considerable amplitude. Something of this kind seems probable in the cases of the Red Spot[3] and the great equatorial current. The motion of the former has been thoroughly discussed by Denning and by Kritzinger independently, and a period of, roughly, fifty years has been suggested. Fig. 7 shows the changes in the position of the Red Spot during the last twenty years. It will be seen that since 1901 the longitude has diminished by well over two hundred degrees. The rotation period attained a maximum value of 9 hours 55 minutes 42 seconds ± in 1899, but in the year 1913-1914 (from opposition to opposition) this had become reduced to 9 hours 55 minutes 35 seconds ±.

Fig. 8 shows the changes in the rotation period of the great equatorial current since 1879. The diagram is based on weighted values derived from the results of various observers (cf. papers by A. S. Williams, M.N., volume lxiii, page 14, volume lx, page 465, volume lxxi, page 145; W. F. Denning, M.N., volume lxiii, page 331; Major P. B. Molesworth, M.N., volume lxv, page 691, and so on), B.A.A. Jupiter Section Memoirs, and so on; and shows that the rotation period in 1913 was practically the same as it had been thirty years earlier. The curve exhibits a slight secondary minimum about 1900, which gives it some resemblance to the light-curves of variable stars of the β Lyrae type; but observations extending over a much longer period are needed to show whether or not the changes are definitely periodic.

Some reference to the present appearance of the planet may be of interest. A comparison of the drawings of 1913 (see Figs. 1 and 2) with those of the current apparition shows that considerable changes have been in progress, and illustrates those characteristics of the surface markings which render Jupiter so attractive an object for telescopic scrutiny. It will be seen from Fig. 5 that the South Tropical Disturbance is now clear of the Red Spot hollow, having just completed its sixth conjunction with that object, and that the Red Spot itself has once more emerged as a well-defined ellipse. To the writer, however, it shows no trace of red, but is neutral gray, presenting a striking contrast to the warm tone of the south equatorial belt. The longitude (ω_2) of the Red Spot at the end of August was about 202 degrees. The South Tropical Disturbance now extends over 110 degrees ± in longitude; the positions (ω_2) determined at Ashtead at the close of August being: Preceding end, 62 degrees ±; following end, 173 degrees ±.

It will be seen that marked changes have occurred in the north equatorial, north tropical, and north temperate regions of the planet. The brilliant egg-shaped markings which in 1913 formed a belt round the north part of the equatorial zone have become degraded into smaller and less regular white areas, while the dark protuberances are also very unequal in size, shape, and distance apart. Observations of thirteen north equatorial markings down to the end of August give a mean rotation-period of 9 hours 50 minutes 17.4 seconds, which is a slight increase on the value of last year.

Among recent developments must be mentioned the formation of dark spots on the north component of the north equatorial belt with white intermediate areas (some of them very bright) on the region between the two components of the belt. Still more interesting is the form assumed by some of the dark markings. They are distinctly arched to the south, and inclose small brilliant white spots, the appearance being suggestive of bridges, or sometimes links of a chain. At least seven objects are of this character, and an idea of their strange form may be gained from Figs. 4 and 5. Observations of seventeen objects in this region show the rotation-period down to the end of August to have been 9 hours 55 minutes 30.6 seconds.

Another striking difference between the appearance of the planet in 1913 and 1914 is furnished by the south equatorial belt. Almost uniformly dark in the former year, it has recently consisted of two widely separated bands with a pale orange region between them.

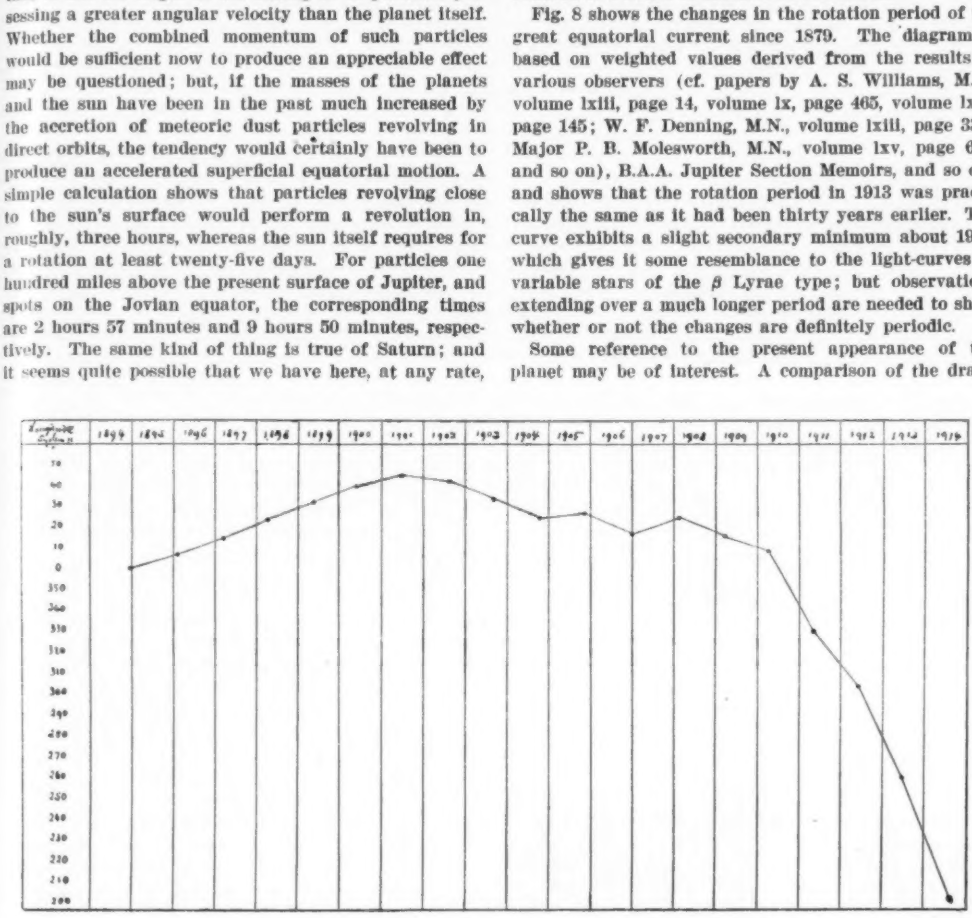


Fig. 7.—Position of red spot at opposition, 1894 to 1914.

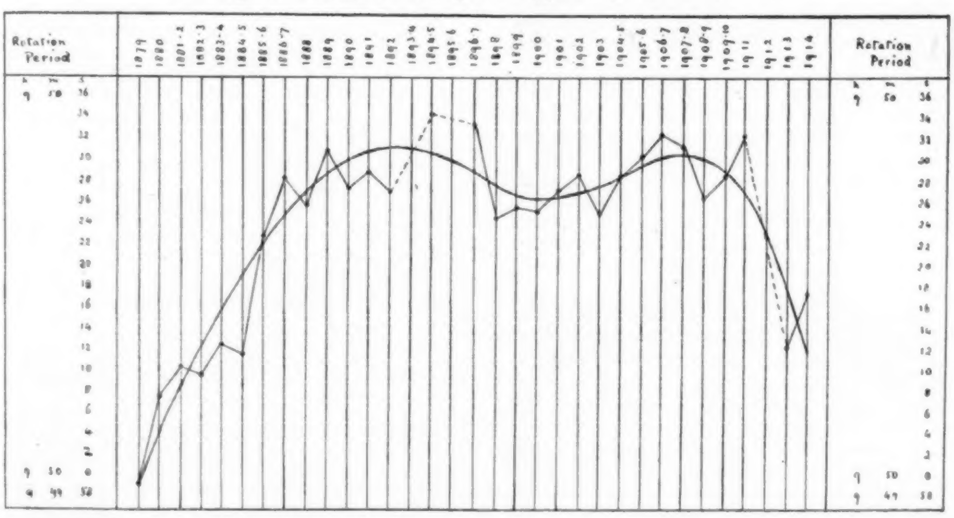


Fig. 8.—Rotation period of equatorial current, 1879 to 1914. The value for 1914 is based on observations from May to August only.

[3] Some of the irregularities in the motion of the Red Spot have been associated with its conjunctions with the South Tropical Disturbance. During conjunction the motion becomes accelerated.

The Physiology of Worry*

By Erle D. Forrest, M.D.

With the possible exception of those in the period of happy childhood, everyone is at times a victim of worry. In fact, the average individual thinks of and accepts worry much as he thinks of and accepts disagreeable weather conditions—as one of the bitter things of life which must be taken with the sweet. In other words, he regards it as a fact, but does not attempt to analyze it. The wisest thinkers of all times have recognized the condition, and many well-known writers have expressed their views of its psychology. What has not been sufficiently recognized, however, until very recently, is the importance of worry, not merely in itself, as implying the absence of happiness, but as the cause of ills far greater than itself, the cause predisposing to secondary manifestations which would otherwise have been, escaped altogether. Having fully comprehended this fact, the next logical step in scientific progression is to determine the exact mechanism by which these disturbances are brought about. Through the conjoined efforts of psychologists and physiologists, we are just beginning to reach the true physical basis of this important subject.

The keynote of worry is beyond doubt a disturbance of the mind. It may be defined as the restless consciousness of all encumbrances which we accept under protest. To elaborate this definition, it is the mind's unrest about anything which concerns us, whether it relates to our future, our dear ones, a cause we have espoused, our happiness, our salvation, our means of support, our position in life, our health, our fate, or our success in general. It does not consist solely in our interest in all these things; it is rather a disquietude arising from a feeling of helplessness before the various chances and claims of life. The popular opinion seems to be that the mental condition is one of depression, possibly because the physical manifestations are chiefly depressive in nature. The fact cannot be too strongly emphasized, however, that the primary mental condition is one of overactivity, and, moreover, overactivity along lines of fixed ideas.

Without taking up individually the phases of worry brought about by the various specific causes, the physical manifestations of worry in general may be said to be—depression of respiration, sighing, disturbances in rate and force of heart beat, vasomotor changes, disturbances in secretion, pallor, cold extremities, relaxation and decreased motility of the alimentary tract, dilatation of the pupil, loss of weight, insomnia and general physical exhaustion. These disturbances may vary in their prominence, and may appear as groups of symptoms characterizing well-known diseases. Thus, worry is sometimes an important agent in the production of diabetes, gout, exophthalmic goiter, and chronic heart disease.

Inasmuch as worry is primarily a disease of the mind, and since every portion of the body is intimately connected with every other part by a net-work of nervous tissue of great complexity, we naturally seek for the causes of these manifestations, first of all, in the nervous system.

In every individual, at a given time, there is a limited amount of potential energy stored up in the cells of the brain. This function seems to rest in the chromatin granules of the nerve cells, and it has been shown repeatedly that a liberation of nervous energy, whether in response to a psychic or sensory stimulus, results in a physiological degeneration of the chromatin granules, and consequently of the cells themselves. Obviously, a prolonged discharge of nervous energy diminishes by so much the amount left in the brain cells. Furthermore, stimuli of sufficient number, intensity, or duration may cause exhaustion and death.

* From the *Medical Record*.

Exactly this phenomenon occurs in the state of worry, except that the degree of fatigue rarely reaches the fatal extreme. Through mental overactivity, and the corresponding chromatolysis in cells concerned in mental processes, discharges of nervous energy to all parts of the body take place through the cerebrospinal axis and the sympathetic system. Whether the action of a given structure is augmented or inhibited, of course, depends upon its inervation. One of the most constant effects of such long-continued discharges, however, is the production of a certain amount of tonic contraction of most of the voluntary muscles, which, if at all noticeable to the individual, he describes as a slight increase of body tension.

A physiological degeneration of nerve cells is normally offset by a slow regeneration, occurring during the periods of physical and mental repose. In worry, because of the fact that the catabolic process is at first more rapid than the anabolic, gradually diminishing as the lower limit is approached, and because continued mental activity gives rise to insomina, a period soon arrives when the expenditure of vital force in the shape of obvious work done has reached a point where the regenerative process, slow as it is, is just about able to offset the breaking down. The phenomena expressing the depletion of the vital force are termed "physical exhaustion." This is to be distinguished from "shock," wherein the stimuli lead to no obvious work done, and the expenditure of energy is extremely rapid.

The sympathetic system, probably because of its intimate relation to vegetative functions, seems to be susceptible to a much slighter degree of stimulation than are the nerves of the cerebrospinal axis. When, in the course of events, therefore, the latter nerves are no longer able to respond adequately to the stimuli arising from the mental activity, the sympathetic is apparently capable of carrying on functions even greater than those which it is normally called upon to serve.

Bearing these facts in mind, we see a possible explanation of some of the various physical phenomena. For instance, stimulation of the sympathetic, with a decreased activity of the motor oculi nerve, causes dilatation of the pupil. Depression of the vagus, phrenic, and intercostal nerves decreases the breath rate. The sigh, so often observed in worried individuals, is simply a very deep inspiration which occasionally takes place to compensate for what would otherwise be insufficient oxygenation of the blood. Through depression of the vagus and the simultaneous stimulation of the sympathetic, the heart action frequently becomes rapid and weak. The vasomotor changes are chiefly constriction of the peripheral vessels, due to stimulation of the sympathetic nerves. In this connection the reciprocal action of the veins of the omentum is brought into play, these vessels often becoming enormously distended with blood. Constriction of peripheral vessels, combined with enfeeblement of the circulation, accounts for the palor and cold extremities so often seen. The secretions are often decreased in amount, through narrowing of the vessels supplying the glandular tissues. The extremely dry mouth and lips which probably everyone has observed when he has been worried is a familiar example of this. The stimulation of the sympathetic may, on the other hand, be so severe as to bring about increased secretion in spite of the diminished blood supply, as is evidenced by the so-called "cold sweat." Inhibition of motility of the stomach and intestines appears to be brought about by stimulation of the splanchnic nerves, again a part of the sympathetic system.

In addition to the nervous system as a means of coordinating the various parts of the body there is a method which makes use of chemical processes. In some of the lower organisms this latter method is the only means of unification and is developed to a relatively high degree. The difference between the two methods is essentially one of time, the nervous system being obviously the more rapid by far. These chemical substances have been given the names "hormones" and "colyones," according to whether their functions are those of augmentation or inhibition. They are all included under the general heading of "internal secretions."

Internal secretions are substances produced by gland cells from raw materials furnished by the blood, which are afterward passed back to the blood or lymph stream, to assist in regulating the general nutrition of the economy, or to serve some more specific purpose of equal importance to the organism. They differ from the better known or external secretions in that in all typical cases the latter are poured out upon epithelial surfaces which communicate with the exterior, while the internal secretions are discharged upon the closed endothelial surfaces of the blood and lymph vessels. With their development in any organism, a susceptibility to their action must arise in certain of its structures. In the broadest sense, internal secretions must be looked upon as something common to all active tissues, but the best known and probably the most important ones are produced in the liver, pancreas, thyroid, adrenals, pituitary body, and probably the ovary, testis, thymus, kidney, and spleen. From the standpoint of their importance in worry, those derived from the pancreas, pituitary body, thyroid, and adrenal glands seem to occupy first place according to the theories evolved as the result of the most recent investigations.

For experimental corroboration of our theories we are compelled to make use of animals, such as the dog and cat, because of the fact that chemicophysiological experiments such as these necessitate extensive and dangerous surgical procedures. Therein lies a great difficulty. Although the animals are readily obtainable we are never sure that a condition of worry analogous to that found in the human organism is simulated. These animals are, however, visibly susceptible to agencies producing fear, and by modifying the results obtained while they are in this state, in accordance with the intimate relation known to exist between fear and worry, many of the theories regarding the influence of the internal secretions may be substantiated.

The function of the internal secretion of the pancreas seems to be that of assisting in the combustion of glycogen, the product of starchy materials ingested as food, in the muscles. Muscular energy is derived from this oxidation, but in order for it to take place two ferments, one produced in the muscle itself, and the other the internal secretion of the pancreas, must be present in quantities of a certain definite proportion. If the balance is destroyed it cannot take place, and the sugar accumulating in the blood to more than the normal percentage appears in the urine.

Two theories as to the part which worry plays in diabetes deserve consideration. The first is to the effect that the pancreatic ferment is decreased, owing to constriction of the blood-vessels in the glandular tissues. The other is that by stimulation of the sympathetic nerves the secretion is increased. The latter theory seems to have the more supporters, but in either case diabetes results from an overturning of the balance between the muscle ferment and the product of the islands of Langerhans.

Worry also seems to increase the internal secretion of the pituitary body. Recent experiments show conclusively that an excess of pituitrin in the blood, without other complications, produces a marked rise of blood pressure and a slowing and strengthening of the heart beat. It appears to slow the heart by acting upon the peripheral endings of the vagus, the nerve whose function it is to bring about that phenomenon normally. An interesting feature of its effect upon vasomotion is that while most of the peripheral vessels are constricted the arterioles of the kidneys are dilated, allowing an abundant supply of blood to those organs. At the same time, pituitrin exerts a direct stimulating effect upon the secreting cells of the uriniferous tubules. These three factors—increased blood supply of the kidneys, increased blood pressure, and hyperactivity of the secreting cells—may well account for the marked diuresis so often observed in worried individuals.

Occasionally, after long-continued worry or extreme fright, the symptom complex—known as exophthalmic goiter—is observed. It probably does not affect an individual unless a previously enlarged or disturbed thyroid gland is present. However this may be, the disease is undoubtedly associated with a hypersecretion by this gland. Since it is supplied by the sympathetic it seems reasonable to infer that this oversecretion is brought about by the stimulation of its controlling nerves. An excess of this substance in the blood, in contrast to the effects of pituitrin, dilates peripheral arterioles, probably by a direct action on the muscle in the vessel walls, bringing about a visible flushing of the skin. It also appears to have an antagnostic effect upon the substances which influence the nutrition of the body, as is evidenced by the rapid loss in weight in this disease and the excretion of large quantities of nitrogen, carbon dioxide, and water in the urine. That it has a definite action upon the nervous system is shown by the tremor usually present. The pulse is at the same time rapid and throbbing in character.

The effects of the internal secretions thus far considered must not be regarded as constant manifestations of this emotion. In fact, the cases are relatively rare in which diabetes and exophthalmic goiter do occur. Inasmuch as we have come to ascribe to all body tissues powers of secretion, is it not entirely reasonable to presume that secretory disturbances in one organ may be offset or held in check in a majority of cases by products of other structures? We know this to be an almost universal principle in animal function, exemplified by the opposed actions of the vagus and sympathetic in the control of the heart. Denied this liberty, we can only, at present, make use of the vague term "individual susceptibility" in explaining this seeming inconsistency.

There is an internal secretion, however, that of the adrenal glands, which appears to be always associated with the most constant effects of worry. Adrenalin, or epinephrin, as it is called, is an excellent example of the manner in which most of the internal secretions and the nervous system interact and supplement each other, for it has been shown that it does not act upon any organ or tissue which has no sympathetic or autonomic nerve supply. In fact, its point of attack appears to be the end arborization of the nerve fiber where it joins the muscle or tissue. The presence of physiological quantities of adrenalin in the body seems to be a necessary condition for the normal functioning of the entire autonomic system.

The secretion of adrenalin is controlled by the sympathetic and is increased in worry. We cannot say that its presence in the blood in abnormal quantities is responsible altogether for the phenomena which are dependent upon the autonomic nerves, for we have seen how the increased stimulation of the sympathetic, by means of mental overactivity, can bring about these things. It does, however, magnify the action of the sympathetic and is capable of maintaining this action alone, for a considerable period of time after the sympathetic stimulation has been removed. The latter phenomenon is accounted for by the fact that there is an autogenous continuance of most of the internal secretions, including adrenalin. In other words, these substances, coming in contact with the tissues which originally produced them, tend to stimulate still further production. After a time, however, even this mode of adrenalin derivation ceases, for the blood gradually gives up its epinephrin by aeration in the lungs.

After the foregoing discussion it can readily be seen that many features of worry have not been considered. This condition, together with its allied emotions, constitutes an enormous field for further scientific investigation. In view of the rapid improvement which modern laboratory technique is undergoing, and the increased interest with which experimentalists are viewing psychophysiological matters, there is a great probability that within the next few years many of the remaining doubtful points will be satisfactorily explained.

Storing Heat

According to a story in *Power* a state dinner was to be given in a castle in Germany in which there was no heating system, but as this mediæval condition could not be tolerated in modern times, for the dinner was a function of recent occurrence, the engineers were asked to heat the building for the occasion; but it was specified that no portion of the heating system was to be visible in the room. The result was accomplished by means of stored heat. For a number of days previous to the dinner, the floor of the dining room was covered with steam pipes and these pipes were kept hot by means of a temporary boiler. The day before the dinner all the pipes were removed and the stored heat in the walls maintained the room in a perfectly comfortable condition for a number of days, although the outside temperature was well below the freezing point.

Organic Matter in the Soil

In the annual report of the Bureau of Soils of the U. S. Agricultural Department is the following statement in regard to the importance of the organic matter contained in soils:

"Organic matter is essential to make a soil of what would otherwise be pulverized and more or less hydrolized rock, and while there are some soils that contain small quantities of organic matter capable of growing crops, on the whole the quantity of this material in average soils is considerable. The average organic content of soils amounts to approximately fifty tons per acre, and yet the nature of this material has been but little understood. It has been believed for many years that it consisted chiefly of some such body as humic acid, differing perhaps in different soils, but having the same general properties. One prominent service which these investigations have rendered agriculture has been to show the non-existence of humic acid and its hypothetical relatives and to show instead the existence of many compounds with many relationships.

"This line of research has been especially profitable during the year just past, and the number of compounds isolated and identified has been increased to more than forty. Some of these compounds contain only carbon and hydrogen; some carbon, hydrogen, and oxygen; some carbon, hydrogen, oxygen, and nitrogen; others contain phosphorus or sulphur. Isolation in a pure condition of these organic constituents of soils has made possible the correct interpretation of the changes that organic matter undergoes in soils. The compounds found are recognized as representing decomposition products of fats, carbohydrates, proteins, and other classes of natural compounds, and a great deal of light is shed thereby on the processes of humus formation and transformation in the soil. These researches into the nature and properties of soil organic matter have shown conclusively that the soil investigator must take into consideration the presence of organic compounds in the soil."

Peculiarities of Earthworms*

Compound Forms That Are Hard to Explain

By Prof. Dr. E. Korschelt

It is not so very unusual to find double or multiple forms among animals, such compound structures in particular not being especially exceptional among segmented worms. Some years ago Prof. Dr. E. Korschelt described in the "Zoological Year Book of 1904" earthworms of double and triple form, peculiarities of structure which had been gained mainly by experiment. He now writes an interesting article in the *Umschau* upon an earthworm with a double rear end, the origin of which is difficult to explain. This earthworm, one of the species *Helodrilus longus*, was found out of doors and was still in an immature state. In crawling the front had measured to the spot where the rear end forked 7.5 centimeters, the right branch of the rear end 4.3 centimeters, the left branch 4 centimeters (Fig. 1).

Apart from the fact that the worm was somewhat clumsier in its movements than one of normal form, its way of moving varied but little from the ordinary. When placed upon loose soil it soon bored its way into the earth and quickly disappeared. When crawling the contractile waves passed simultaneously from the front end to both rear ends, which worked normally during the crawling. The transmission of irritation was as usual from the front end to the rear ends and *vice versa*, a point that was easily settled by touching the end of the head or of the tails. From this may be deduced the continuity of the main nervous system, as well as of the vascular system and of the intestinal canal. The arrangement of the rows of bristles and the way they fit into each other is best seen from Fig. 2. At the forking there is some irregularity in the arrangement of the segments which overlap suitably to the dividing of the body (Figs. 1 and 2). In Fig. 2 is shown by dots the respective positions and course of the rows of bristles from the ventral side upward.

It is not possible to determine from the condition and manner of action described whether this anomalous structure has existed from the beginning, that is, whether it is the result of the development of the embryo, or whether the double form has arisen from an injury. If the worm had been injured when young so that a new rear end grew out from the wounded spot, or if the tail end had been completely lost and, on account of a suitable conformation of the surface of the wound, two rear ends grew out of this, there could follow under the circumstances, a far reaching rearrangement of the segments and it would hardly be possible to determine the difference of this form from a double structure arising from embryonic development. This has been proved by a fairly large number of double-tailed worms produced by Dr. Korschelt by means of experiments. He says further:

"During some earlier exhaustive researches observations were made as to the length of an earthworm's life, which led to the surprising conclusion that these worms can live ten years and more. The writer is now able to give more exact information as to the conditions of their life. It is entirely accidental that these observed worms were ones upon which transplantations had been made. It was not intended at the time to determine the length of life but merely to watch the changes which might arise from the operation made upon the worms. For this purpose they were subjected to observations covering a long period of time. In addition, the selection of the species of earthworm, *Lumbricidæ*, was also accidental and was brought about by the kind of operations made upon them, just as this, on the other hand, influenced the life of the respective worm. The life of the *Eisenia* (*Allolobophora*) *fœtida* was, for instance, a relatively brief one, being from 3½ to 4½ years. This brevity of life can be accounted for in this way; either the unions of parts were such as not to have much vitality, or external circumstances affected the length of the respective experiment and shortened the period of observation. This latter explanation holds true for the single specimen of *Lumbricus terrestris* (*L. Herculeus*) which was kept for a considerable length of time and which lived to be 5¾ to 6 years old. Experiments were made on a larger scale with the *Helodrilus longus* (*Allolobophora*) [*Lumbricus*] *terrestris*, and somewhat by chance a large number of specimens of this species of earthworms was preserved for experiment, and for these worms the carrying out of the experiment permitted as a matter of course a longer lease of life for the united portions. The respective specimens lived for 6½, 7½, and 10¼ years."

It should be remembered in connection with the ages given that these were worms which were kept in confinement under rather limited conditions of space. The question could be raised whether these conditions are not more likely to produce a prolongation rather than a curtailment of life, as the imprisoned worms lived in comparative inaction and their forces were only exerted to a small degree. It is difficult or indeed hardly possible to answer this question with certainty so long as we know nothing positive on this point concerning worms that lead a natural life, especially as we do not know whether they pass through longer or shorter periods of inaction. In general, the earthworms are probably not much affected by unfavorable conditions of temperature and weather, as it is possible for them to go down to considerable depths in the ground. How far they really do this cannot be determined with certainty from the observations so far made. It seems that earthworms go down

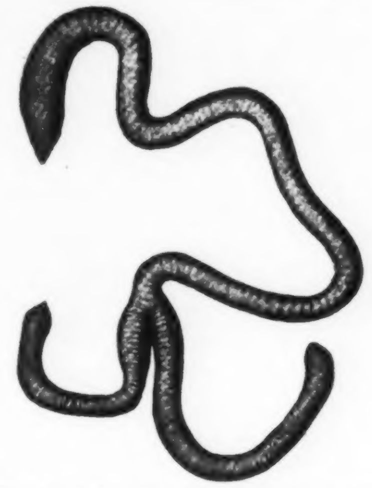


Fig. 1.—Rain worm with double rear end.

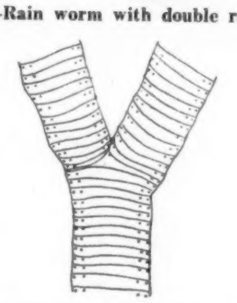


Fig. 2.—Arrangement of bristles at point of separation. Evident irregularities of the segments.

2 to 2.5 meters in the ground. Their burrowing can be easily traced down to 2 meters, so that those which are long enough lived to do this seem to be well protected against the cold. On the other hand, frozen earthworms have been found in the ground at about a depth of 0.5 meter. The question here is whether such worms could not awaken to new life if the cold were not too severe and too long continued.

There have been repeated accounts of earthworms on and in ice and snow. Experiments in freezing them have also been made which show that earthworms, and also other Oligochætæ, can bear relatively low temperatures without permanent injury. Dr. Korschelt made experiments with various Oligochætæ which were exposed for a considerable time in glasses of water to the almost complete freezing of the water. The experiments were up to 24 hours in length at a temperature of 5 deg. Cent. and lower, and the worms began to move again after the water gradually thawed out. They were absolutely vigorous and were observed for weeks further. Taken altogether, earthworms seem to have less power of resistance, although in the experiments made on them they always bore temperatures down to 5 deg. Cent., for though they seemed to be frozen stiff they always revived to fresh life.

"It is safe to deduce from these experiments and observations which have been continued up to the present time," continues Dr. Korschelt in discussing his experiments, reports on which he has published in various scientific journals, "that the worms under natural conditions can bear a fairly low temperature, go through a certain condition of freezing and then wake up to a new life. Earthworms which are dug up in winter after a period of frost hardly move at all and seem frozen, but in the temperature of a room they soon become more animated and crawl about. It is most probable that the earthworm goes through a period of torpor something like hibernation at a considerable depth in the ground. At any rate, just as such early observers as Morren, Hoffmeister, and Hensen stated, they are found in the enlarged ends of pipes, rolled up in a ball either singly or in nests."

According to observations made upon imprisoned earthworms by our author, they can also pass through periods of torpor of another kind, namely, periods which protect them from droughty conditions. When moisture is lacking for them they withdraw into the depths of the ground as far as possible, and they are found rolled up close together in an underground hollow which has fairly firm walls, smooth on the inner side and apparently held together by a secretion of the worm. If the torpidity lasts a good while, the worms lose decidedly in volume, become shorter and show retrogression, especially of the genital region. This may be explained by the loss of water and the insufficient amount of nourishment taken during this "dry sleep." If this condition does not last too long and the worms become moist again, they then come out of the earth-capsule and under normal conditions resume their former mode of life.

"These observations show a certain agreement with those communicated by several other investigators but traced to other causes," says Dr. Korschelt. "Thus W. Harms remarks when making experiments in transplantation, that the earthworms lying in a round hollow would tie themselves up into a 'tight knot' after they had stopped taking nourishment while still moist and when sufficient nourishment was present. The worms, consequently, had fallen into a kind of 'heat torpor,' in which if it lasted too long, certain retrogressions of their organisms would appear similar to those described above in 'dry sleep,' and this could lead to considerable reduction in size, as a shortening of the body. Somewhat different are the statements made by Vejdovsky, according to which his observations concerning the appearance of torpidity in earthworms both out of doors and in imprisonment were not to be traced to conditions of temperature and weather, but rather to exhaustion after continued sexual activity. That those earthworms which had burrowed down into round holes in the ground had also, as in the above mentioned cases, suffered a reduction of the genitalia as well as one of the bulk of the body seems very probable from Vejdovsky's statement. As the holes in the ground have a fairly firm wall, Vejdovsky speaks directly of an 'encysting,' and compares it with the encysting of another Oligochætæ, the *Aelsoma*, which both he and Beddard had observed. This latter, a water worm, when unfavorable conditions appear, secretes around itself a layered envelope in which it lies curled up. It thus passes through the unfavorable weather, and when conditions are once more suitable it comes out of the envelope. The author himself has had occasion to produce by suitable measures the encysting of this worm in a thickly populated Aeolsoma culture and thus to confirm the observations made by the two above-named investigators."

The exceedingly scanty number of observations concerning the torpidity and encysting of the Oligochætæ has just been increased by an observation made by Mrazek on the *Claparèdeilla*, another worm which lives in the water. These worms are accustomed to live at spots which are exposed to drying up. When there is danger of this dryness they creep under the fallen leaves in the deeper layers of mud, roll themselves up here and secrete around themselves a glutinous covering. In Mrazek's opinion this action may also have another meaning, namely, that processes of separation in the organism of the worm may take place within this capsule.

The object of these communications was to compare the prevailing conditions among earthworms with those existing among the other Oligochætæ, and by the appearance of undoubted periods of torpidity among the latter to strengthen the conclusion reached concerning the former. This does not settle the point how far these conditions of existence affect the question of the age attained by earthworms, but even if certain reductions have to be made in the figures of 6, 8 and 10 years obtained for the ages by direct observation, the figures that remain far exceed all expectations.

*Translated from *Umschau*.

A Russian Embargo on Woods

The Forest Service of the Department of Agriculture is authority for the statement that the Russian government has placed an embargo on all kinds of lumber, to prevent its exportation; walnut lumber, including Circassian walnut, much prized by American furniture makers, is specifically mentioned.

Showing cofferdams, molds, and reinforcing bars of the piers of the Pennsylvania viaduct.

Concrete Viaducts on the Pennsylvania Railroad

Replacing Insecure Wooden Trestles With a Substantial Road Bed

By Day Allen Willey

When the Pennsylvania Railroad Company built its line from Philadelphia to Washington the use of concrete for viaducts and bridges was unknown to the engineer. When the surveyors went over the proposed route between Havre de Grace, on the south of the Susquehanna, and Washington they found it necessary to make soundings of three inlets to the Chesapeake named the Bush, Gunpowder, and Back rivers, and it was found that the beds of these inlets consisted of liquid mud to a depth of over fifty feet. The plans for bridging these inlets provided for wooden trestles, the supports consisting of wooden piles driven into the mud formation which formed the bottom of the inlets and strengthened by a double row of braces fastened diagonally between each pair of piles.

The structure was so weak owing to the uncertainty of the foundation that parts of its frequently gave trouble, delaying train service until the defects could be remedied. The engineering department has always realized the necessity for permanent viaducts over the Bush and Gunpowder rivers having firm foundations, and it was decided to replace the frame structures with reinforced concrete viaducts.

The right of way was ample, but it was desired to put in the new bridges with as few new curves as possible, and these conditions were met by throwing the new bridge alignment on a slight angle with the old. The center line for the bridges was carefully laid out and measured on the ice in the winter, making careful corrections for temperatures, and using a standardized tape.

The old bridges were used as base lines and the new line was tied in at numerous points. At each bridge site a small concrete pier was erected on the shore for locating the center line, with three wooden blocks inserted for the tripod legs, and the point was located on this pier, and a foresight was carefully placed in the water. Thus, practically all the points were located using a foresight. Permanent backsights were established, but were only used when the foresight was obscured by smoke, hazy weather, etc.

The river mud was of the consistency of silt and was removed by pumping. The piling for the foundations was driven by steam hammers, attempting to reach the desired penetration with each pile. In some cases, however, it was impossible to obtain the penetration necessary, probably owing to the piles striking a conglomerate. Whenever it was impossible to obtain the desired penetration two extra rows of piles were driven for the pier, and the footings were spread. Wooden cofferdams were used, constructed of 6 by 10 sheet piling, which were driven with a small rapid action steam hammer. The pumps which excavated the mud were located on a small barge, and no difficulty was experienced in pumping the material 2,800 feet through 12-inch pipes. The piles were cut off so as not to extend more than 2 feet into the footing, provided the desired penetration was obtained. Where the first pile in the pier brought up above this point the remainder of the piles were sawed off accordingly, so little cutting off was necessary after driving.

To make a solid and firm bed for the concrete foundation a large wooden funnel was built, with an opening so small that the gravel would not run out fast enough to stir up the mud. This funnel was loaded with gravel and slowly moved around over the cofferdam. This process was continued until a layer one foot thick was placed, and then it was ready for the concrete.

A concrete plant was built on barges at each river. A large hopper divided into two parts was kept supplied with sand and stone by a clam shell bucket, unloading from barges alongside. The cement was stored on the main barge, and in the first plant built, at Bush River, the cement was carried to the mixer by laborers. In the other plant the cement was carried forward by an endless chain conveyer.

The concrete was raised in an elevator to the top of the tower and poured through the piping into the forms by gravity. The collapsible forms for the connecting arches were made of 3½ by 3½ by ¼ inch angles in five parts. The upper ones were bent to the radius of 4 feet 3 inches. Quarter-inch boiler plate was bolted to these angles, and the angles were bolted to the wooden pier lagging, and aided considerably in holding the pier forms in proper alignment.

The economy of steel truss supports is apparent, there being about 200 spans of the same length in the two structures. These trusses were set up on jacks and upright timbers with wedges between, resting on horizontal transverse timbers, which in turn were supported on the pedestals of the piers.

Jack screws were used to bring the trusses to the proper height, also to let down the trusses when striking. The trusses were lowered directly onto a barge, and towed to the next pier by a gasoline tugboat. The forms for one span were frequently collapsed, hauled to a new position, and jacked up into place in three hours.

Expansion joints were provided at every third pier. These were made by layers of cheap felt paper, making a thickness of one inch. The footing is 10 feet wide, 33 feet long and 6 feet thick.

The piers and footings are provided with steel reinforcing to take care of unequal strains or settlements. The footings have 1-inch square twisted steel bars as follows: 2 longitudinal bars 33 feet long, just outside the vertical pier bars; 10 transverse bars on about 3 feet centers, with an extra one between the two bars at the center of the piers.

The tops of the floor slabs have a drainage slope from all directions to the 4-inch drain pipe placed at the center of the slab, so water can flow directly into the river.

An idea of the extent of this construction, which was let out in one contract, is given by the following quantities of material needed: Combined length of bridges, 7,714 feet; total number of piles, 13,777; number of yards excavated (wet) 97,000; yards of concrete masonry, 76,400; reinforcing steel rods, about 3,850 tons.

There are 186 duplicate regular piers, two abutment piers, two rest piers, and one center pier, all of reinforced concrete, with pile foundations. The footings, 6 feet deep, are made of concrete mixed nominally in the ratio of 1:2:4, and an additional 20 per cent of cement to compensate for wash due to the deposition of the concrete under water. Bottom dumping buckets were used in the cofferdams before the latter were pumped out.

Work was commenced on the viaducts March 15th, 1912, and the entire structure was completed September 15th, 1913. Considering the difficulties encountered in connection with the pier work, the construction was completed in a remarkably brief period, the average working force being only 400.

To test the strength of the viaducts a train of 50 loaded freight cars, each car weighing 60 tons and drawn by one of the most powerful locomotives in service, weighing over 100 tons, was hauled over the structure at a speed of 25 miles an hour without causing the slightest vibration.

Concrete mixing and distributing plant on one of the Pennsylvania viaducts.

Actual Instances of Dual Personalities—II*

Cases in Real Life That Rival the Wildest Fiction

By Edward Tyson Reichert, M.D., ScD., Professor of Physiology in the University of Pennsylvania

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The history of Mary Reynolds was reported by Dr. S. Weir Mitchell to the College of Physicians of this city in 1888. The subject was a very impressionable girl. A nervous shock resulted in the development of multiple personalities which existed over a period of years, her normal personality, as in the cases of the fictitious Dorothy and the real Miss Beauchamp, being restored by hypnosis.

Miss Reynolds's family moved from England to the wilds of western Pennsylvania during the early part of the eighteenth century. She is said to have possessed an excellent mental capacity and to have enjoyed fair opportunities to acquire knowledge. Besides the domestic arts and social attainments, she had improved her mind by reading and conversation. Her memory was capacious and well stocked with ideas. She was sedate and reserved, and tended to melancholy. When eighteen years of age she had hysterical fits, and after one of these attacks was blind and deaf for six weeks. About three months later, after having almost wholly recovered her normal health, she fell into a profound sleep, which lasted about twenty hours, upon awaking from which memory had completely fled, and she was to all intents and purposes a being for the first time ushered into the world. Her parents, brothers, sisters, and friends were not recognized; the scenes to which she was accustomed—the house, hills, field, forest, vales, and streams—were new. She began to learn, but always when in this new personality she looked upon those she had once known as strangers and enemies, among whom she was by some remarkable and unaccountable means transplanted, though from where she had not the remotest idea. She learned to read and write, but her handwriting was not the same as that of her primary state.

Instead of being melancholy, she was cheerful to extremity, buoyant and sociable. Formerly taciturn and retiring, she was now merry and jocose, extravagantly fond of company, and enamored of nature.

Six weeks after the appearance of her second personality she fell into a protracted sleep, from which she awoke in her primary state, recognizing the members of her family, remembering what she had planned as though but yesterday. She was absolutely without memory of the events of existence of her second personality, and was greatly surprised at the change that occurred in nature over night.

Remaining in her primary state for a few weeks she again fell into a sleep from which she awoke in her secondary personality, now beginning life where she had left it weeks ago when she re-entered the life of her primary self, having now only the knowledge of her secondary state. Her vivacity, wit, and humor were now so great as to make her company very much sought, but her love of playing tricks upon others often led to much trouble. Alternations in personality went on for fifteen or sixteen years, the secondary personality tending to remain for increasingly longer periods, when she assumed the second personality, continually existing in this state for the remaining twenty-five years of her life without the least knowledge of her other self beyond what had been told her.

Another case, in some respects similar to that of Miss Reynolds, and known as Félida X, was studied by Dr. Azam, and has become world-renowned. Félida came under Dr. Azam's observation when fifteen years of age. She had had many hysterical and other troubles, which led to her becoming a timid, serious, grave, and melancholy individual who was burdened with anxiety and pain. Appearing to faint away for a few moments, she would awake, having an entirely different personality. Her pain, anxiety, and other mental and physical infirmities had vanished, and she was gay, vivacious and coquetish and morally perverted. She remembered the incidences of her normal life, as did Sally of the life of Miss Beauchamp, but when in her primary state, like Miss Beauchamp and Miss Reynolds, she had no knowledge of her secondary state. These personalities alternated with great frequency, but the primary state lasted for shorter and shorter periods, and was ultimately crowded out, as it were, by the secondary state, as in the case of Miss Reynolds, which thereafter constituted her constant personality.

It is probable that in the cases of Miss Reynolds and Félida the personality which at first was recognized as the secondary personality was in reality the primary personality, or normal state, and hence that the personality that was ultimately established was in reality not the secondary, but the primary.

In these cases of dual personality the nature of the change in the individual's moral character may differ very widely. We have seen in the instance of Dr. Jekyll and Mr. Hyde a form of moral monstrosity that is manifested in an inherent maliciousness and a demoniacal pleasure in the infliction of torture on others—a form of immorality that arouses hate, fear, and loathing. In the cases of Becky, Sally, Mary Reynolds and Félida there were forms of moral perversion that led to the annoyance of themselves or others, or of such a kind as to engender sympathy. The most pathetic among these instances of marked moral alienation was that of a young woman, recently a patient in this city, who in her natural state was the personification of all that is attractive, lovely, and sublime in young womanhood, and who at times upon awaking from a deep sleep would have an entirely different personality, with manifestations of moral monstrosity that vied in vileness with those of the denizens of the tenderloin.

In many cases the secondary personality appears but once, and sooner or later gives place to the normal. An interesting instance belonging to this category was reported by Dr. Osborne. The subject was a man of middle age, in admirable health, very fond of his family, and not known to have any eccentricities, morbid tendencies or bad habits. For years he had resided in a town near this city, and by strict application to his business, which was that of a tinsmith and plumber, had been successful and accumulated some means. One dull and gloomy Sunday in November he mysteriously disappeared. He had remained in the house, mainly engaged in reading and playing with his younger children, until 4 o'clock. Arising from a couch upon which he had been reclining and reading, he said that he was going out for a short walk and a little fresh air. Leisurely, quietly and apparently perfectly normal, he stepped outside of the door to disappear as mysteriously as though the earth had swallowed him.

Two years later in a tin shop in one of the southern towns where a number of men were engaged at work, one of the men suddenly dropped his work, and, press-

* A lecture delivered at the University of Pennsylvania, December 19th.

ing his hands to his head in a dazed way, exclaimed: "My God, where am I? How did I come here? This is not my shop. What does it mean?" At first the men were disposed to laugh and jest at the man who for several months had been so reserved and sober, and who had worked so quietly by their side, but of whose history they knew nothing. Seeing his changed expression, his face wet with perspiration and his nervous twitchings, and hearing his piteous appeals, they became startled and called him by a name that was strange to him, yet the one he had given them. Trembling with suppressed emotion, he made his way to the proprietor, and with some difficulty made the proprietor understand his true condition and the story of his northern home, family and prosperous business, which, as it seemed to him, he had left but the afternoon before. Under the assumed name he had been known and paid, but the entire period from the time he left home until the present was a complete blank. After ascertaining the whereabouts of his family he joined them, and from last accounts was living the life of his normal self.

A variable number of different personalities may develop in a given individual, the person living as many different lives, each being partly or wholly ignorant of the existence of the others. Thus, a man by the name of Monks, a son of wealthy people who lived in London, lived four different lives, mingling in four different classes of society and having four different sets of friends. As a conscientious clerk he was quiet, retiring, deferential, cared little for the society of women, did not smoke, and was extremely exemplary in his habits. As a professional bicycle rider he was loud-voiced, boastful, swaggering, profane, a smoker and a drinker. As a society man he was a fashion plate in his attire, of graceful ease, and extremely popular with the ladies, four of whom in different parts of London he was engaged to marry. As a burglar he was most skillful and daring, and it was only after years that shrewd detectives ran him down and, not knowing of his peculiar mental state, had him committed to prison as a common criminal.

A case of a man having six personalities was reported by Bourru and Burot. In the first personality he was talkative, violent, arrogant, rude, disrespectful, antireligious, embarrassed in speech, and with limited though precise memory. In the second personality he was reserved, gentle in speech, orderly, respectful, without religious opinion, and his speech was easy and pronunciation clear, and he had little memory of the past. In the third personality his state was very much like the second, but his memory was limited entirely to the third state. In the fourth personality he was timid, sad, well-mannered, and his intelligence was obtuse, his memory confused, and his language incorrect and childish. In the fifth personality his mental state reverted to the period when he was fourteen years of age. He had the timidity, language and attitude of a child, and was without memory of any of the incidents of his life subsequent to this time. In the sixth personality he was a proper young man, a soldier of the marine corps, and his memory embraced his entire life excepting the period known as his fourth state.

In a young girl as many as ten personalities were developed in twenty months, and in one of them she reversed everything—to her white was black, heat was cold, etc., and even her writing was reversed.

Among all of these remarkable cases of dual personality none is, on the whole, so interesting and so instructive as that of the Rev. Thomas C. Hanna, which was carefully studied by Drs. Sidis and Goodhart ("Multiple Personality," 1905); and no summary, however brief, would be adequate without at least some reference to this extraordinary record. The differences in the personal traits, the complete loss of memory in the secondary state, the gradual childlike acquisition of knowledge, the childlike wonderment of what was seen and heard, and the ultimate recognition of the existence of two personalities, with their separate lives and their final blending, form one of the most absorbing stories in psycho-physiological literature.

The Rev. Mr. Hanna was born in 1872 and had an exceptionally good family history and all the advantages of an excellent education and was a good scholar. He entered the Manual Training School of this city and his high scholarship gained for him admission as a free student to the Architectural School of this university. During his stay with us his sense of religious conviction became so awakened that he gave up his studies for those of theology, and in order to prepare himself for the practical duties of the ministry he took up missionary work.

He had an earnest, ardent, sympathetic and impulsive nature; was well balanced, and possessed a strong will combined with perfect self-control. We find him at twenty-five years of age the pastor of a church at Plantsville, Conn.

At 7 o'clock one Thursday evening, when attempting to alight from a carriage, his foot caught in a lap robe and he fell head foremost, striking his head, and when picked up a few moments later life seemed almost extinct. In this state he remained for two hours, then began to move, looked around in a bewildered way, rose from the bed, and in a dazed manner attempted to push aside one of the physicians. His three attendants, believing him to be delirious, seized him and attempted to force him back to bed, but Mr. Hanna's strength, while ordinarily excellent, now seemed herculean, and his opponents were readily worsted. Finally, he was overcome and securely bound with straps, for fear of his injuring himself or others. While now having the physical strength of an exceptionally robust man, his mind was a blank, as void as though he had just been ushered into the world. He saw, smelt, tasted and touched, but these senses conveyed absolutely no meaning excepting as to mere light and darkness and color. Objects, space and time were without intelligent perception. There was no perspective sense; everything, irrespective of distance, appeared close to his eyes, giving him the impression of one great picture. An object seen through the window appeared as near as his outstretched hand, and he would not have had any hesitancy in attempting to grasp the moon.

Sensations of hunger gave rise to great distress, but without arousing the least knowledge of the reason. Food placed in his mouth did not excite any sense of its use. He made no attempt to either masticate or swallow it, and in order to feed him it was necessary to force food back into the pharnyx to cause reflex or involuntary swallowing movements.

Bodily movements alone at first attracted his attention, and he learned in time to distinguish between movements of his own body and those of other people and things. He gazed at moving objects with the wonderment of the young infant, and after he had learned to associate movements with life he thought all moving objects living things, the swaying of the branches of a tree appearing to him movements of living creatures, and the horse and carriage a single living object.

He heard conversation, or noises as he termed them, and in time recognized that by their means people could understand each other, and although he had not the least idea of the meaning of a single word he thought he could learn to communicate with others by repeating the noises he had heard. Hence, he would again and again repeat in his mind these sounds, and then repeat aloud words and sentences he had committed to memory; but he was surprised to find that he was not understood, and for a time he became discouraged. Not knowing the meaning of his utterances, his speech was, of course, utterly unintelligible. It was not until the lapse of two days that he had learned the real meaning of a single word.

By this time he was able to recognize time by the difference between daylight and lamplight and by the recurrence of the three daily meals. His education may now be said to have been fairly started. He began to understand, speak, read, and learn to walk.

Owing to his mental faculties having been highly developed, and to his inherent capacity for rapidly acquiring knowledge, he learned with amazing rapidity, even to the attainment of accomplishments that were unknown in his normal life. Thus, he learned in a few hours to play the banjo, an instrument with which he had had absolutely no experience.

For nearly two months he remained in this mentally childlike state, gradually but with extraordinary rapidity acquiring the elementary knowledge common to early childhood; having absolutely no knowledge of his existence before the accident or of his actual relations to the people about him, and developing during this period an entirely distinct personality, as different from his normal as the personalities of two people differ. His memory was so keen during and after this period that upon his ultimate recovery he was able to give a minute account of his experiences and thus unfold a remarkable history of incidents such as presumably are attendant upon the education of the infant and very young child.

The period of second personality lasted for seven weeks and was ended by his falling asleep and awaking as the Rev. Mr. Hanna, he now having absolutely no remembrance of what had transpired since the moment of the accident. He thought that the accident had occurred the evening previous, and when told that it was seven weeks ago he thought the speaker jesting and the story a huge joke.

He had been in New York for some time, but he failed to recognize his surroundings, and the people who had been in constant attendance for weeks past were absolute strangers, excepting his brother, the only one he had known in his normal state.

In the midst of the conversation he suddenly exclaimed, "What a funny taste in my mouth; you must have been feeding me on tobacco." Before going to sleep he had smoked a cigarette, but not having used tobacco for many years and not having any knowledge of the events of the previous evening he could not in any way account for the taste. When asked how he felt, he said "I feel just like Rip Van Winkle." After remaining in his primary state for three-quarters of an hour he fell asleep, awaking in his second personality, his mental life beginning where it had ceased upon falling to sleep the night before, he not having a vestige of knowledge of what had transpired between the two periods of sleep.

From this time on there followed frequent alternations of the primary and secondary personalities, the transition from one to the other occurring without obvious cause and with increasingly greater frequency. The alternations were for a time wholly unknown to Mr. Hanna, excepting in so far as he was informed by others; and owing to the very different memories of the two states more or less serious embarrassments were caused.

With the passing of time the frequent alternation of personalities, the gradual acquirement of knowledge during the periods of his second personality, and the increasing information received from those about him of his mental dual existence, there came a moment when he clearly recognized the existence and differences of two personalities or mental lives. Struggles of the two for the possession of the body occurred, at which times Mr. Hanna would be in a dazed state, and in neither one nor the other personality. What went on in Mr. Hanna's mind was quite accurately remembered by him and is well set forth in a statement made by Mr. Hanna to Drs. Sidis and Goodhart:

Mr. Hanna stated that while lying upon a lounge in one of these dazed conditions he had engaged in one of the most intense struggles he had ever experienced. The two personalities, the primary and secondary states, rose simultaneously and confronted each other. Each of them was the "I," still they differed from each other. The memories seemed to be those of two different persons, yet he recognized that both were his. He could not choose one because it differed from the other, nor could the two be joined. The struggle produced great perplexity and perturbation. He felt that both were his, yet it seemed impossible to unify them. One could not be abandoned, because both came up constantly before him as though exclaiming, "We are one, though different." It seemed as if each said to the other, "Thou art a mortal foe, and yet thou art bone of my bone and flesh of my flesh." Each it seemed had for a time tried to crush or suppress the other. The question in his mind was which of the two lives he should reject, and then the struggle was not so much to choose one as to forget the other, both persisting in his consciousness as though each memory was stronger than his will. Each memory seemed to be within the same physical being, as if there were two bodies alike, like twins, that had lived entirely different lives, or like twins of the same body with tastes, faculties, and natures very similar. The time came when he realized that he must take one or the other personality. The decision was difficult and the mental struggle great, but he finally decided to adopt both, because of the fear and anxiety that the struggle would be repeated again and again, and that the mental agony of these recurrences would be too great to endure. And so in time the two personalities, differing so much, were fused into one healthy, normal, mental individual—into one Ego, or I, the present Mr. Hanna.

The passing of the hour permits of but an additional word. We are creatures not only of to-day, but also of yesterday. In the secondary personality of Mr. Hanna we found evidence as development proceeded of the presence of his primary state and in the latter state of his secondary state. Time and again one state would force itself into the other, each for the time struggling for mastery, finally one letting go, as it were, the better or the worse state becoming for the time the Rev. Mr. Hanna.

In each of us the Ego, or I, is not a unity, but a duality, a blending of primary and secondary selves, of conscious and subconscious mental lives, of mental processes that, broadly speaking, express the human and animal sides of our natures. As one or the other may for a time dominate so are our personalities modified. As the speaker is uttering sentence after sentence he is conscious of the occupation of the mind with the phrases of the moment, but beneath this consciousness there lies a most potential mental life, or background, which, while seemingly latent or wholly beyond the field of consciousness or introspection, is extremely active—a life that embraces memories of past experience of self and countless ancestral individuals. It contains the fundamental structural material or sense-images or memories from which all our thoughts are built and moulded.

Our physical peculiarities are heritages that go back into the dim past, and they are expressions of causes that had origin beginning in time unknown; our mental lives are heritages that likewise have come to us

through a countless line of ancestors for thousands of centuries. The impress of our progenitors upon our mental lives is not less than upon our physical lives. Just as each of us has an Ego that is a blended duality that is readily separable into two different selves, so has each of us a dual immortality—an immortality of the soul that is ours alone, and an immortality of the mind and flesh that is transmitted to our offspring and which passes from generation to generation. The emotions and thoughts of thousands of preceding generations and the acts of the lives of the barbarians, savages, semi-educated, educated and cultured individuals who through the course of time have ultimately given us birth, echo and re-echo in our beings. Their personalities, like their bodies, have been born and reborn in their children and children's children, to be born and reborn for better or worse in ourselves and our offspring.

Some Features of Photo-Chemistry*

Are They the Results of Electrical Phenomena

By H. H. McHenry

The subject of photo-chemistry is one about which comparatively little is known. While the applications to ordinary photography are well understood, the theory that leads to the chemical action of light is far from being perfectly comprehended.

The photo-chemical process has two phases. The production of a compound is one phase, such as the production of chlorine knall-gas. The other is decomposition, such as the decomposition of hydrogen phosphide with separation of phosphorus. This latter phase is by far the more common. The chemical action of sunlight, such as that shown in the bleaching process, the production of green colors in plants, and the well-known action of light used for blue-printing, have been known for centuries. Only recent investigations, however, have taught us that numerous compounds are sensitive to light, and convinced us that here we are dealing with a mutual action between ether vibrations and chemical forces. By experiment it is found that the chemical action of light takes place only in special cases, as it is held that illumination can exert an influence on the reaction velocity of a system which is in the process of change, or on a system in the state of equilibrium which is in chemical repose.

Before discussing the theory of the ether vibrations, it might be well to cite a few features of ordinary photography. The modern chemical method employed in development rests on what is known as the "latent light-action of the silver salts." A gelatine film impregnated with silver bromide is first illuminated and then treated with reducing agents. The silver haloid in the plate is then reduced to silver most quickly. At the illuminated spots this reduction results in the formation of free halogen, but the nature of the reduction product is not known in all cases. On the illuminated spots of the plate small particles of metallic silver are deposited by reduction, their density increasing with the intensity of light, but always in such small quantities that no visible change occurs in the substance of the plate. When the plate is put into the developer, those invisible silver particles act as nuclei for the precipitation of silver, just as small crystals bring about crystallization in a super-saturated solution. The denser the silver particles at any spot the denser will be the deposit of silver during development.

A valuable aid to photography was furnished in a discovery made by Vogel in 1878. He found that photographic plates may be made more sensitive by intermixture with slight traces of organic coloring substances. Also the plates are usually especially sensitive for kinds of light absorbed by particular coloring substances. Thus plates may be prepared sensitive to yellow, blue, or red, or any colored light. This phenomenon is called optical sensitation. So far no theoretical explanation has been given for it.

As light is thought to be a phenomenon occasioned by ether vibrations, the theoretical consideration of its chemical effects must lie with these vibrations. When ether vibrations traverse a material system, they occasion two different results. First, they raise the temperature of the system, their energy being partly converted into heat. Secondly, they occasion chemical changes, occurring at the expense of some of the energy of vibration. The first phenomenon is known as the absorption of light, the second as the photo-chemical absorption of light. Gases, liquids, and solids all respond to ether vibrations, such as the explosive mixture of hydrogen and chlorine, chlorine water which gives up oxygen under the influence of light, and white phosphorus which changes to the red modification, in light, or cinnabar which turns black. While photo-chemical action may be produced by any type of ray, it depends on the wavelength of the light used, like ordinary absorption.

A set of empirical laws of photo-chemical action, compiled by Eder, serves as an aid to understand the chemical action of light-rays. They are: (1) Light of every wavelength is capable of photo-chemical action. (2) Only those rays are effective which are absorbed by the system, so that the chemical action of light is closely associated with optical absorption, although the converse is not true. (3) According to the nature of the substance absorbing light, every kind of light may act in an oxidizing or reducing way. The red light has an oxidizing effect, and violet light a reducing effect on the metals. (4) Not only the absorption of light rays by the illuminated substance itself plays an important part, but also the absorption of light by a foreign substance mixed with the principal substance, for the sensitiveness can be stimulated for these rays which are absorbed by the admixed substance. (5) A substance sensitive to light, admixed with the main substance, and which unites with one of the products resulting from photo-chemical action (as oxygen, bromine, or iodine), tends to accelerate the reaction velocity to such an extent that reversal is impossible. This may be regarded as a consequence from the law of mass action.

As stated above, these laws can only be regarded as empirical. There are some exceptions, notably, to (3). Red light exerts a reducing effect in the case of the latent light-action of the silver salts, while violet oxidizes organic compounds, especially colorless ones. These laws were ascertained by means of instruments known as actinometers, which measure the intensity of the chemically active rays. The idea of actinometers is a most important one. All pieces of apparatus which are designed to measure this intensity, and which collectively depend upon the observed changes which are experienced by substances sensitive to light when under the influence of ether vibrations, are called actinometers. The data obtained from actinometers of all kinds must be considered as having a purely individual nature. They give only a *relative* measurement of the intensity, for if the same kind of light is used the nature and reaction velocity of the chemical process occasioned in each case will vary according to the behavior of the system which is subjected to the action of light. Also, when the light used consists of rays of different wavelength, the data of the same actinometer will by no means be proportional to the intensity of light, as the action of light varies greatly according to its wave-length.

It might be well here to consider a few types of actinometers. The eye can be considered an actinometer, because, apparently, its sensitiveness to ether vibrations depends upon certain photo-chemical processes which are thereby occasioned. However, the results of visual photometric measurement are not parallel with those obtained by actinometers, and neither results are parallel to those obtained by thermometric measurements. The latter is usually regarded as an absolute measure of radiation. It would perhaps be more correct to regard the diminution of free energy, which is unknown, associated with the change of radiant energy into heat, as the measure of the intensity of light.

A simple form of actinometer is that known as the chlorine knall-gas actinometer. It depends on a discovery of Gay-Lussac and Thenard in 1809, who found that, when strong light acted on the combining of chlorine and hydrogen, the velocity increased rapidly to the point of explosion, and, when weak light acted, it progressed slowly and steadily. The method consists in measuring the diminution of a volume of chlorine knall-gas (standing over water, and maintained at constant pressure and volume) as a result of the formation of hydrochloric acid, which is absorbed by the water. This actinometer was constructed by Draper in 1843, and, later, improved by Bunsen and Roscoe.

These two men discovered the silver-chloride actinometer, in which the time required to darken a photographic paper until a definite "normal" shade is reached is taken as a measure of light-intensity.

Another interesting actinometer is the electro-chemical actinometer. Two silver electrodes, which have been chlorinized or iodized, are dipped into a dilute solution of sulphuric acid. Electromotive force will be established between the electrodes, and as long as one of them is illuminated the current will flow in the solution from the unlighted to the lighted pole. The strength of the current is read by means of a sensitive galvanometer, and this serves to determine the intensity of the light. Results obtained by this actinometer agree approximately with those obtained in photometric ways. This actinometer was constructed by Becquerel in 1839.

Attention may now be turned to the work performed by chemically active light. One would expect the light to be absorbed to a greater degree when it occasions, or accelerates, a chemical process than when such is not the case. Bunsen and Roscoe found that when light passed through a layer of chlorine knall-gas it was much more weakened in its chemical activity than when it passed through chlorine alone. In both cases the light is weakened by absorption by the chlorine: the absorption by the hydrogen can be neglected. But in the first instance, absorption is purely due to optical activity, and, therefore, the loss of energy reappears in the heat developed. In the second case, however, an additional fraction of light-energy is consumed in performing chemical work, which thus occasions a stronger absorption. This phenomenon is called photo-chemical extinction.

A word may be said as to the speed of chemical light-action. Bunsen and Roscoe found that light usually acts very slowly at first, and only attains its full activity after a lapse of time. This is called photo-chemical induction. Pringsheim succeeded in showing that this phenomenon is due to the formation of intermediate compounds. As chlorine knall-gas is more sensitive to light when moist than when dry, it seems probable that hydrogen and chlorine do not unite directly to form the acid, but that a series of intermediate compounds is first formed. Also a slight preliminary exposure of a photographic plate renders it more sensitive, and an under-exposed plate is strengthened by a subsequent exposure.

The physical laws which chemically active photographic rays obey are of peculiar interest. They are reflected, refracted, and polarized like other rays, their intensity diminishing as the reciprocal of the square of the distance from the point of origin. Research work has shown that when light of the same kind is used, the photo-chemical action depends solely on the product of the intensity and the duration of exposure. It has also been proved beyond doubt that the time required for the development of a normal color on sensitive paper is proportional to the number of light-waves which strike the paper per second.

One important difference between photo-chemical reaction and ordinary reactions is that the velocity in the former increases but little in a rise of temperature, while that of the latter increases enormously. We are led to believe that light action should not be regarded as a direct loosening of the atoms in a molecule such as that effected by heating, but rather the primary effect must be some action on the luminiferous ether, and suggests ionization.

Now what is the cause of these light-vibrations? The latest authorities maintain that light-vibrations are produced by electric agitations, and that in the chemical action of light we deal with phenomena not far removed from the formation and decomposition of compounds under the influence of the galvanic current. That chemical equilibrium is affected by illumination follows from the change in the thermodynamic potential of components by illumination, as may be more clearly deduced from the electro-magnetic theory of light. It has been proved that electrification and magnetism alter the thermodynamic potential, and the action of light-waves is, according to the most advanced theories, that of rapidly alternating electric fields. From these conclusions we may assume, at least until further knowledge of the subject is gained, that the ultimate cause of the photo-chemical action of light lies in electric phenomena.

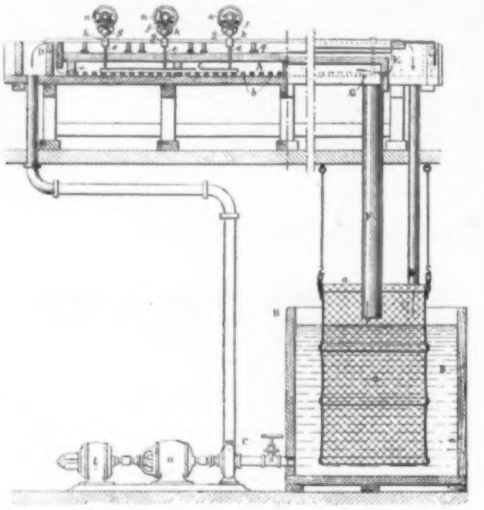
* Reproduced from *Knowledge*.

A New Recreation Region

The Forest Service of the Department of Agriculture directs attention to a little known region that offers unusual attractions to sportsmen and others who enjoy an outing in the open. It says the Uinta Mountains of Utah, included within the Wasatch, Uinta, and Ashley national forests, should become a favorite recreation region because of the many small lakes within depressions scooped out by glacial drifts. Seventy such lakes can be counted from Reid's Peak, and one particular township, thirty-six miles square, contains more than a hundred.

Protecting Silvered Mirrors by Copper Plating

The fact that the silvering of mirrors is subject to deterioration from various causes has given rise to no little trouble in this branch of the industry; but this has been entirely overcome by the new French process invented by Declère, Gresy and Pascalis for producing a protecting coat of electrolytic copper upon the silvering of mirrors, especially as regards mirrors of large



Sectional views of Gresy coppering apparatus.

A, electrolysis vat; *B*, vat containing the reserve solution; *C*, centrifugal pump; *D E*, outlets fitted with cocks; *F*, emptying pipe with valve *G*; *a*, cotton filter; *b*, pegs to hold plates; *e*, brass rods forming the teeth of the comb; *f*, nut holding the teeth of the back of the comb formed by bars *g* and *h*; *n o p*, arrangement for raising the teeth of the comb; *q*, anodes; *t*, dynamo generating the electrolysis current; *u*, motor.

size. Architects often hesitate to put large mirrors in new buildings on account of the frequent deterioration by dampness and the emanations from fresh walls. Another source of trouble comes from saline air on the sea coast, which cause damage to mirrors in these regions. For a long time a good method of protection has been sought for not only against dampness, but also from such gases in the air as sulphurous anhydride, sulphuretted hydrogen and others. Direct use of varnish should be avoided, because of the presence of bitumen and other substances; and moreover, varnishes have been found insufficient protection and are not durable. The chemist Liébig's method was to cover the silver plating with an electrolytic coat of metal, but this very rational plan has up to the present time been limited to small optician's and surgeon's mirrors because of the difficulty of applying it on a large scale. The present idea refers to mirrors which have been coated with silver by a deposit of that metal on the glass from a suitable bath; and the object is to extend the Liébig process to looking glasses of all sizes, such as are so widely used in shops and public buildings.

Up to the present time it has only been possible to connect the electrolytic current by contacts placed at the edges of the mirrors to be protected, which plan had the serious inconvenience of producing deposits thicker at the edges than in the center of the mirror, by reason of the great electric resistance offered to the passage of the current by the thin silver coating. The center of the glass thus received a very slight covering of copper.

The great difficulty has been to multiply the metal contacts direct on the surface of the silvered glass, so that the density of current should be uniformly distributed. By the direct application of the contact on the surface of the mirrors, there was the risk of doing considerable damage to the delicate silver plating, the thickness of which is well known to be infinitesimal (about 0.0005 millimeter).

The Declère, Gresy and Pascalis process does away with these inconveniences. The most interesting and characteristic part of the process is the system of the "rheophores" which distribute the current by the aid of hundreds of contacts which, by simple devices, are brought into delicate contact with a silvered mirror, and distribute the current equally over the silvered glass.

Because of their multiplicity, each contact possesses a very limited field of action, and as the contact is made by hundreds of points distributed over the glass, only a small amperage is delivered at any one place, thus avoiding the violent action which dividing the useful effect of this current in a very uniform manner without loss. The deposit of copper thus obtained is perfectly continuous and homogeneous, and does not admit dampness or any other cause of alteration.

The negative "rheophore" is forced by a sort of comb made up of brass wire teeth, each of which makes a contact with the silvered surface, and forms a center of distribution. The expenditure of current is very small, and the rods of the "rheophore" are sheathed except at their extremity in such a way that the electrolytic deposit is laid equally over the surface of the glass.

By this new process it is possible to manipulate as many pieces of glass as the vat will contain, so that one can obtain the maximum of production at the same time with the smallest space. The system of anodes used in the process is extremely simple, inexpensive and rapid, and offers the advantage of covering only the glass to be treated.

The use of the under reservoir permits the electrolytic vat to be emptied as soon as the operation is over, and the mirrors are washed and left to dry in the vat. The handling of the glass during the process is thus avoided, with the economy of not having to provide a special washing vat.

The consumption of electrolytic liquid is also much reduced by the present construction of the apparatus, and the active circulation of the bath in the vat, by means of a centrifugal pump, results a continuous filtering out of the impurities in the bath, thus leaving no trace of them on the copper deposit. The cost of the current and of the electrolytic liquid is strictly proportionate to the area of the plates to be coppered.

The general operation of the apparatus is simple and regular and essentially practical, and the average workman can execute the copper plating perfectly after a few explications and on glass of any dimensions.

Description of the Plant.—The apparatus consists of two tanks, the top one of which, *A*, is that used for the electrolysis. The other tank, *B*, generally placed underground, contains the electrolytic solution which a centrifugal pump *C* forces continually to the inlet *D*, where suitable guide pieces direct the current toward the surface to be treated. The solution passes through vat *A* and returns by an outlet *E* to the vat *B*, where all impurities are removed by passing through the filter *a*. By means of a large pipe *F*, with a valve *G*, all the liquid may be sent back to vat *B*, when the operation is finished. The wooden electrolytic vat *A* is fitted at the bottom with pegs or cleats *b* to support the plates *c*.

"The "rheophore" is formed by a comb, the teeth of which consist of brass rods *e* attached to the bar *h* by nuts *f*, and passing easily through the bar *g*. The lower end of the teeth *e* are tipped with tin, a soft metal which is not liable to damage the silvering. The teeth are moreover surrounded except at the bottom end, by an insulator, generally consisting of a covering of paraffine. The lower bar, *g*, is fitted at each end with a flexible cable *k*, by which it receives the current from copper

General view of coppering plant.

conductors *e* which connect with the negative pole of the source of electricity. The cable *k* is joined to the conductor *e* by the clamp *m*. The bar *g* is rigidly attached to bar *A*, and the gears *o*, operated by the hand wheel *n* and shaft *p*, raise or lower the bar *n*, thus regulating the contact of the teeth *e* with the surfaces that are to be copper-plated. The rheophore may be lifted out of the vat as shown in Fig. 1, to facilitate the manipulation of the plates.

The anodes are formed by copper strips *q*, each strip being fixed to a wooden bar, as shown in Figs. 2 and 3. A dynamo *t* generates the necessary current and gives about five volts and thirty amperes per square meter of glass to be coppered. The pump *c* and dynamo *t* are generally placed on the same shaft with the motor *u*.

Rangefinders

Of the many instruments designed by the engineer for the more accurate conduct of naval warfare none is of greater importance than the rangefinder. In the days of Nelson no such device was necessary. To come to grips ships of war were obliged to approach so near to one another that there was rarely any doubt about accurately laying the guns, and any error could be promptly corrected. In modern warfare conditions are very different, and a naval engagement of the first order of importance may take place with the units of the opposing fleets separated by miles of ocean. But the engagement, says the London *Daily Telegraph*, can only come to a satisfactory conclusion if the rangefinding

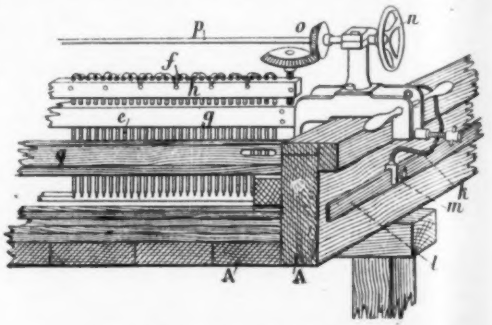


Diagram showing details of apparatus used.

has been accurate, and the range within the limits of the guns for an adequate period. With projectiles costing some hundreds of pounds apiece, and the possibility of disaster if one of these misses its mark, it is clear that for rangefinding to-day the unaided human eye is no longer of the value it was in the days before the coming of steam and the ironclad.

Since the eighties, therefore, much ingenuity has been directed toward obtaining an instrument which, at a glance, would indicate correctly the distance of any object within range of vision, one of the latest types being an anti-aeroplane instrument. This is so mounted that the base of the instrument swings in a vertical plane, and the eyepiece is situated in the line of the trunnion, thus enabling the rangetaker to make observations with comfort upon objects at practically all altitudes. The mountings of such rangefinders are specially designed to enable a rapidly moving object to be kept under continuous observation.

A single observer rangefinder may be regarded as consisting of two telescopes mounted in a common frame with the two objectives situated one at each end of the frame, and with the eyepieces at the center, suitable reflectors being provided at the objectives to direct the beams of light along the frame toward the eyepieces, and the whole arrangement being such that the combined telescopes may be simultaneously directed on the same target. The rangefinder itself forms the base of a triangle, having at its vertex the object, the range of which is determined by measuring the parallax, i. e., the angle subtended by the base of the instrument at the object. Two beams of light from the distant object are received by reflectors at the ends of the base, and are transmitted through two objectives toward the center of the instrument, where another pair of reflectors placed one over the other reflect the beams outward through the eyepiece. Each objective forms an image of the distant object in the focal plane of the eyepiece, and the observer, therefore, sees in the field of view two images, which, depending upon the type of instrument used, may overlap one another or be separated by a fine separating line.

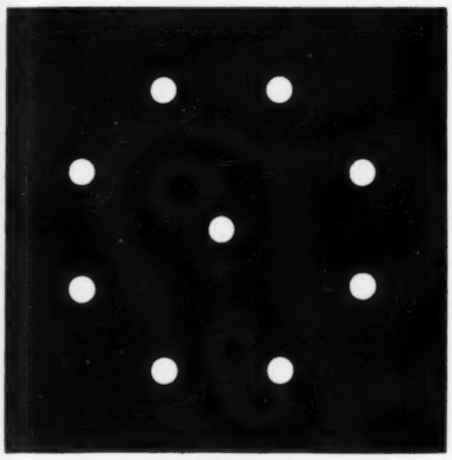
Optical or mechanical devices are adopted in rangefinders of this class for altering the course of one or other of the beams of light within the instrument, so as to bring the two partial images into correct coincidence or alignment, and a scale is provided for indicating the distance of the object, the scale or its index being moved by the gear used for bringing the images into alignment.

Plant Only Certified Potatoes

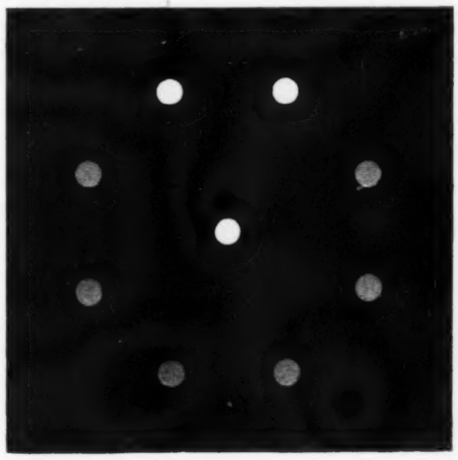
In some sections of the country potatoes are infected by a powdery scab, and as a result these districts are quarantined by the Department of Agriculture, which has issued a warning to farmers and others that in procuring seed potatoes to use only such as come in sacks bearing the while label of the Potato Inspection Service. Table potatoes for the general market are shipped in bulk, and the car alone bears a blue certification tag, so it is not desirable to buy ordinary eating potatoes for seed purposes. Some dealers are said to be selling eating potatoes for seed purposes, and while they are not violating any law, those who buy this kind of seed are liable to find they have introduced a dangerous disease and are liable to quarantine. The white seed certificates relate only to freedom from powdery scab and not to the quality of the potatoes; still those in certified seed sacks are apt to be more carefully selected than the average stock.

Guide Lights on Aviation Fields*

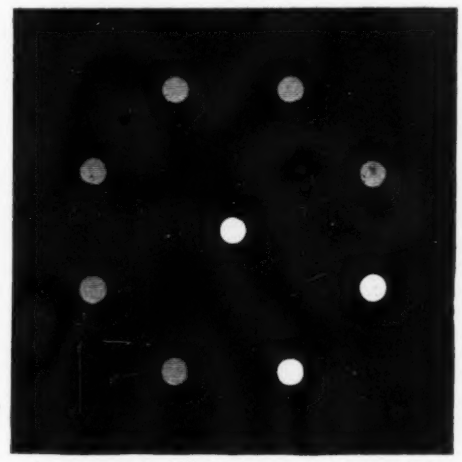
THE aviation field at Johannisthal, Germany, is to have an underground lighting system which will indicate for the nocturnal aviator the best place for landing and the direction of the wind. The lights are inclosed in iron boxes, which are covered with round panes of very thick glass and are sunk in the ground to their tops. Eight such boxes are arranged at equal distances in a circle the center of which is marked by a ninth box. Each box contains a red and a white electric light, and the current, conveyed by underground cables, can be switched into either light by hand or by an automatic device operated by the wind. The direction of the wind, which by day is shown by a canvas imitation of an aeroplane landing against the wind, is correspondingly indicated at night by three white lights. Two of these lights, marking consecutive vertices of the octagon, represent the wings of the aeroplane, while the third, at the center, represents the tail. The other five lights are red.



All lights are white in a dead calm.



Arrangement of lights for a north wind.



Arrangement of lights for a southeast wind.

Of the eight principal points of the compass that can be indicated in this way, that one is shown which most nearly represents the actual direction of the wind. The landing is made against the wind by steering the aeroplane over the central light and midway between the other two white lights. In a dead calm all of the lights are white and the landing can be made in any direction. In the accompanying illustrations, as in maps, the top is north, the right side east, etc. The white lights are represented by white circles, the red lights by shaded circles.

The Function of the Earth in Radio-Telegraphy†

A LECTURE on the above subject was delivered on Friday evening, November 13th, by Dr. J. A. Fleming, to the members of the Wireless Society of London, at the Institution of Electrical Engineers. Dr. Fleming said that the present period of enforced inactivity for all loyal radio-telegraphists, except those engaged at the seat of war, offered an opportunity to reconsider some of the purely scientific questions involved in the art. He proposed therefore to discuss the function of the earth in radio-telegraphy. Apart from the disputed question whether the aerial wires should preferably be earthed at the base or connected to an insulated balancing capacity, it was well known that the nature of the soil or surface between the transmitting and receiving stations had a great effect on the signal strength. This effect depended much upon the wave-length. Thus Dr. L. W. Austin had shown that the ground to the north and northeast of Newport, Rhode Island, U. S. A., exercised a powerful absorption on radio-telegraphic waves of about 1,000 meters wave-length. Experiments made between Brant Rock wireless station and the United States cruiser "Birmingham," lying at Newport, showed that whereas electric waves of 3,750 meters wave-length suffered little or no absorption in traveling over the forty-five miles other than that due to the normal space decrease of energy, waves 1,000 meters in length lost 95 per cent of their signaling energy in passing over the same district.

Dr. Fleming first gave a brief mathematical discussion showing the manner in which the gradual penetration of an alternating current into a conductor can be explained. It is well known that high frequency electric currents are confined to a thin skin or layer of the surface of metallic wires. In the case of copper this skin has a thickness of about 0.25 millimeter for currents of a frequency of one million. In the case of iron the skin for the same frequency is about 0.02 millimeter.

An elegant experiment was shown by Dr. Fleming with his cymometer to illustrate this surface flow of high-frequency currents. An oscillation circuit was arranged in which high-frequency currents were generated, and these were detected by placing alongside a cymometer having a Neon vacuum tube as a detector of secondary oscillations in its circuit. In the primary oscillation circuit were inserted successively small spirals of copper, brass, iron, and galvanized iron, all having the same size and same number of turns. The oscillations in the cymometer circuit were indicated by the brilliant glow of the Neon tube. When the iron spiral was inserted the Neon tube did not glow, because of the damping of the oscillations caused by the energy absorbed to magnetize the iron. The galvanized iron spiral behaved, however, just like a copper or brass spiral, because the oscillations did not penetrate through the thin layer or skin of zinc into the iron. If, however, this zinc was oxidized or broken, then the iron core exerted its effect in damping the oscillations.

Dr. Fleming then explained that when a radio-telegraphic wave passes over the earth it penetrates to some extent into it, and also loses amplitude owing to the absorption of wave energy by the soil. The depth of penetration or depth in which the forces attenuate to ϵ^{1} or to 0.368 of their surface value, and the horizontal attenuation or distance in which the surface values decrease to the same fraction of their original value can be calculated as shown by Dr. Zenneck when the values of the soil conductivity, soil dielectric constant, and frequency are known. Thus taking the generally accepted values for sea water for waves 1,000 feet in wave-length, the penetration into the sea is at most about one meter. In the ordinary dry soil it may be 100 or several hundred meters. There is a certain soil conductivity and wave-length which gives the maximum attenuation of the wave over a given distance.

The calculation of the depth of penetration and attenuation of the wave with distance can be made when this soil conductivity and dielectric constant is known. Recent researches have shown, however, that the conductivity of imperfect insulators for alternating currents is much greater than for direct currents. Dr. Fleming referred to researches by himself and Mr. Dyke for proof of this fact. Lately, he said, Mr. Bairsto had continued this work in his laboratory for currents of extra high frequency of one or more million, and found their dielectrics had a maximum conductivity for a certain high frequency. The inference from this was that the earth was an incomparably better conductor for the high frequency curves used in radio-telegraphy than for ordinary low frequency or steady currents. Dr. Fleming then went on to consider the propagation of an electric wave over the earth's surface, and pointed out that Sommerfeld had shown that when a Hertzian oscillator had one half connected to the earth there would not only be space waves through the dielectrics (air and earth), but a surface wave along the surface which would consist in longitudinal electric currents propagated as a wave motion along the surface. Dr. Fleming pointed out that this surface wave might be the explanation of the well-known facts that signals from long distance wireless telegraph stations can be picked up and detected without any high receiving wire, merely by connecting one end of the receiver to the earth and the other to any insulated mass of metal in the interior, it may be, of a house.

Passing then to the consideration of the diffraction of long electric waves round the earth, Dr. Fleming gave a brief account of the state of the theories advanced by Poincaré, Nicholson, Macdonald, and Rybczynski. These agreed that the amplitude of an electric wave sent out horizontally from any point on the earth's surface diminished according to an exponential function of the distance and wave-length. The last named analyst had shown that this function was of the form $\epsilon^{0.0015r/\sqrt[3]{\lambda}}$ where r is the distance of the sending and receiving stations and λ is the wave-length. Actual observations by Austin over distances up to 1,000 miles had led to an empirical formula differing only in that $\sqrt{\lambda}$ appears instead of $\sqrt[3]{\lambda}$.

The bulk of the evidence so far collected as to long distance transmission showed, however, that true diffraction of space waves or even the surface waves could not contribute more than a moderate fraction, perhaps not 20 per cent, to the total observed result. The chief part of the effect for distances of 3,000 to 4,000 miles must be contributed by space waves which had reached the receiving station indirectly, that is, after reflection or refraction at the surfaces of layers of high-altitude ionized atmospheric gases in the manner explained by Heaviside and by Eccles.

The great variations in signal strength taking place from day to day in long-distance wireless intercourse proved that this must be the case.

In conclusion, Dr. Fleming exhibited a chart showing the variation in the strength of the signals received at University College, London, from the Eiffel Tower station in Paris at 11 A. M. each day during last July, prior to the outbreak of war. The sudden falling off on certain days was remarkable. Dr. Fleming said that the further examination of the cause of these variations was one of the chief objects of the British Association Radio-telegraphic Committee which was appointed at Dundee in consequence of a suggestion made by him, and that as soon as the present calamitous world war came to an end it was hoped these researches might be resumed.

* Adapted from Capt. Engel's article in *Prometheus.*

† From *Nature.*

Concrete Wine Cellars

IN the region of Champagne, in France, the wine in bottles is stored in vaulted cellars which are hollowed deep down in the chalk strata, but it is observed that cellars of this kind are not always of the healthiest, for infiltrations of water are likely to occur. This not only has a bad effect on the quality of the wine, but may give rise to a cave-in of the roof. Reinforced concrete comes in here to furnish a solid vaulting that does not depend on natural conditions, and recent structures were put in with a comparatively light vaulting and straight walls, with concrete flooring as well. The result is a watertight construction which can be kept perfectly clean. An example is seen in one of the cellars at Epernay, where the reinforced concrete shell vault follows the outlines of the chalk-cut cellar, but there is left an air space all around of 4 to 8 inches thick, and an air circulation is produced by making suitable openings to the outside. The inside of the vault or cellar has no connection with the exterior part, and is thus kept dry and in the best condition.

Preserving the Forests

GREAT areas of valuable timberlands are destroyed by fire every year, and not only is this an immediate loss, but the effects will be felt more severely as time passes. The Forest Service of the Agricultural Department is doing splendid work in fire prevention, which can be appreciated by facts recently published in relation to what was done in the Boise national forests in Idaho during the past summer. Thirty fires occurred in this region, yet twenty-eight were held down to less than ten acres, and of these fifteen were less than one quarter of an acre. The supervisor says this success was due to a lookout tower and to efficient telephone and heliograph service.

"Suction" Between Passing Ships—I*

Important But Little Understood Forces Affecting the Motion of Vessels

By Sidney A. Reeve, M.E.

"Suction" is a term commonly applied by pilots to at least three distinct hydraulic phenomena associated with moving vessels, between which phenomena they distinguish most vaguely, if at all. These three quite independent actions are:

1. The direct impulse embodied in the streams of water projected astern by screw or paddle, independently of any motion of the ship itself.

2. The direct effect of the mass of water which follows a ship bodily when it is moved slowly through restricted waters.

3. The indirect, or lateral pressure, effect of the fore-and-aft acceleration of the water displaced from bow to stern during normal motion through the water at full speed.

Of these, the first two are most simple and obvious, hydraulically speaking, because there the force exerted is aligned with the water's motion. In the case of the last, the force developed hydraulically acts at right angles to the line of the water's motion. The first two need no explanation, and have nothing in common (speaking scientifically) with the third. They play an insignificant part, if any at all, in the majority of "suction" collisions, and are mentioned here chiefly for the purpose of eliminating them from further discussion. They are of frequent occurrence in the daily handling of shipping about crowded wharves, and for want of another name, or in lack of official definition, they are frequently called "suction" by the (American) Admiralty Courts; but because they are seldom of sufficient violence to be of importance, and because they are more of the nature of a "puff" than a "suck" the term "suction" will be used here as excluding them.

Historically speaking, while the science of hydrodynamics has been developed chiefly by British—or, at most, European—students, yet the recognition of suction as a feature of importance in navigation has arisen virtually exclusively in American experience. The sources of information are the books and the Admiralty Court records. Previous to the Olympic-Hawke collision in 1911 there was no literature on the subject known to the writer, excepting Taylor's paper of 1909, describing his Washington experiments. Search of the British Admiralty records by deputy discloses not a single reference to the subject. Marsden's "Collisions at Sea" (London, 1910) makes only a single reference to "suction," saying:

"A vessel will be held in fault if, without necessity, she navigates so close that . . . . she is affected by the wash or suction of the ship ahead and will not answer her helm,"

referring by footnote to the American cases of the McCandless, Mariel, Brockton, and Chicago. No search of French or German court records has been made, but the principal German work devoted to ship collisions ("Der Zusammenstoss von Schiffen," Dr. Richard Prien, Berlin, 1899) makes no mention of the subject, which could hardly have happened had it ever been discussed by the German, or even by any European, courts.

In American waters the earliest instances of ship-action which were probably suction, although not given that name, occurred in 1846 and 1847, in the "Naugatuck"-"Rhode Island" and "Governor"-"Worcester" collisions. By 1869 the phenomenon had found official name, as "suction," in the "Narragansett"-"Providence" collision. From that time forward the appearance of the thing was frequent, albeit at irregular intervals. In 1871 are recorded two cases, in 1877 two, in 1880 five, in 1883 one, etc. All of these occurred in restricted inland waters. In 1885 occurred the first case involving Atlantic liners, when the "Aurania" and the "Republic" came together by suction outside Sandy Hook (but not in deep water).

Excepting possibly the records of the Naval Courts of Inquiry, which are inaccessible, the sole source of data as to actual cases of suction collision is the testimony before the Admiralty Courts. This testimony, it must be understood at the outset, is almost universally incompetent and contradictory. England's sole experience, the "Olympic"-"Hawke" case, was merely typical in this respect. The trouble is not that the witnesses are incompetent as navigators. The trouble is that navigation normally makes no demand for the estimate of the distances in feet or yards. The pilot is accustomed to gauging his distance from outlying buoys or other ships in terms of his vessel's speed or rate of swing, but not in feet. Again, when called upon afterwards for the data essential for an analysis of the collision, he can give, instead of systematic observations or estimates, only his subconscious guess as to what must have been the conditions in order that the known results should have followed, which he does in perfect sincerity. Or even if estimates were actually made, they must have been made at times of great excitement and responsibility, when positions were altering rapidly, and when the pilot's mind was properly occupied with other things.

In one case the witness was the captain of a prominent trans-Atlantic liner, a man of dignity and experience. As he testified, the writer plotted the ship's position on a large scale-chart. Had the statements been correct, the ship must have been aground all the way down the harbor. Yet so obvious was the skill, experience, and sincerity of the witness that even opposing counsel made no attempt to impeach his statements. Both sides accepted the testimony as competent to prove that his ship was well over to that side of the channel on which he (virtually) testified that she was aground. In another case the court found, from the combined testimony of competent witnesses, that it was a physical impossibility for a collision to have occurred; but since both vessels were injured the hypothesis as to the facts is necessarily a compromise which includes a collision.

For all these reasons the formation of any accurate deductions as to the distance or angle at which suction becomes an overwhelming force is an impossibility, even for any one case. When the influence of such widely varying factors as ship-model, speed, sea-bottom, etc., is included, it becomes obvious that any hope of securing from experience or theory a *quantitative* law of suction must be abandoned at the start. But even without this, a *qualitative* understanding of the forces at work in "suction" can be of the greatest value in warning pilots as to the general conditions under which it is liable to occur, and as to where a larger margin of caution than usual is needed. For such a qualitative understanding of "suction" a brief incursion into theoretical hydraulics is necessary.

Stream-lines: "Sources" and "Sinks."—Imagine a body of water of uniform depth and unlimited lateral extent, in which is placed vertically, and extending from bottom to surface, a straight pipe of small diameter. Imagine the sides of this pipe everywhere perforated with many small holes, so that it can discharge or take in water on every side throughout its entire length. Let it be connected at the foot with some unlimited reservoir of water below the sea-bottom, so that it can draw water from this reservoir or discharge into it to unlimited extent, just as a "grounded" wire can draw electricity from the earth, or discharge into it, without limit. Disregard all question of friction of flow within the pipe, so that the capacity of the pipe for handling water is independent of its diameter, the speed of flow being anything imaginable. Therefore, for convenience, let the pipe be represented, in plan, by a geometric point.

Such a point as this, when drawing water from below and discharging it into the sea, is called a "source." When the flow is in the opposite direction it is called a "sink." Thus a source would radiate water horizontally in the sea, away from it as a center, in all directions equally. Conversely, a sink would draw water to it horizontally in all directions.

"Stream-lines" are mathematical functions of the volume of flow of water which can be represented conveniently and accurately on fields of co-ordinates, and which can be added, subtracted, etc., like other mathematical quantities. They may be of any imaginable form, and may be either of two or of three dimensions. For present purposes, no presentation of the mathematics of stream-lines is needed; nor do we need the three-dimension functions, which are much more intricate to handle than the two-dimension. Only those particular forms of two-dimension lines which pertain to the analysis of "suction" will be mentioned, and for an understanding of their mathematics the reader is referred to the bibliography listed later herein.

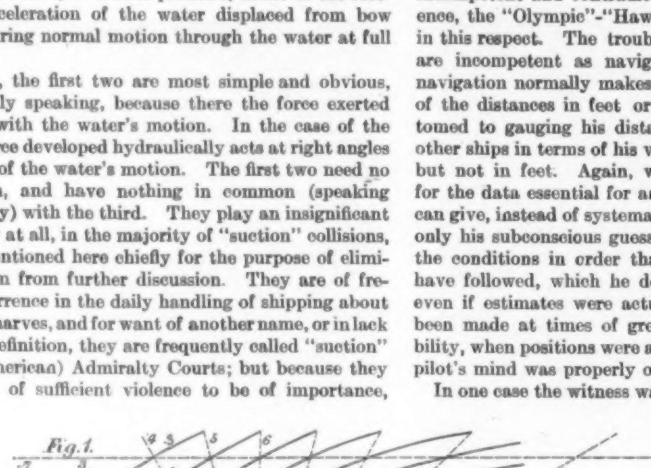


Fig. 1.

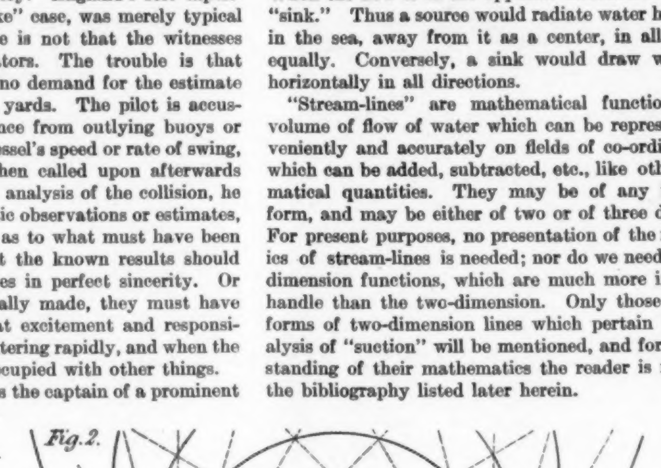


Fig. 2.

From a "source," or toward a "sink," radiate straight stream-lines, like the spokes of a wheel. Physically speaking, each stream-line represents a sector of flow of water, measured from some radius taken arbitrarily as a zero axis around to the radius or stream-line in question. Therefore the angle between zero axis and stream-line is the mathematical measure of its quantity, and this quantity of flow is the same at all distances from the center. Any convenient angle may be taken as the unit angle, or an arbitrary quantity of flow may be taken as the unit. According to the number of such units stream-lines radiating from a "source" or "sink," the latter is said to have different "strengths."

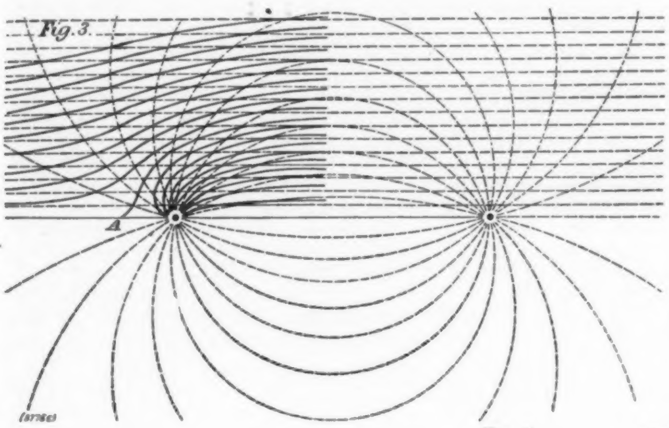
In a canal of uniform, rectangular cross-section, in all portions of which the rate of flow was the same, the stream-lines would be straight lines parallel with the banks. The distance from the bank would be the mathematical quantity of the stream-line.

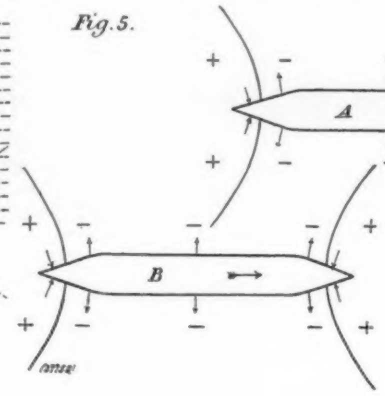
Fig. 1 shows the addition of two such sets of stream-lines, resulting in a third set. The radial stream-lines are given numerical values, from "zero," at the axis of the figure, around to "24" for an angle of 360 degrees. The parallel lines are given similar values—positive below the axis, and negative above. Selecting any desired value for a resultant stream-line, the line can be located as passing through the intersection of each pair of original lines the sum of whose values equals the desired value. Resultant lines are thus found having values ranging from "zero" for the stream-line crossing the axis at right angles and rising above it, increasing around to the right until the same line below the axis has the value "24." From the "zero" resultant line above and to the left are lines having negative values. Below and to the left are those having values above "24." Both positive and negative series extend indefinitely away from the center of the figure.

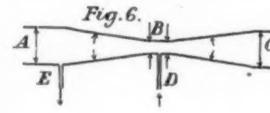
Such a set of resultant stream-lines would give the effect of placing a "source" or a "sink" in a uniform

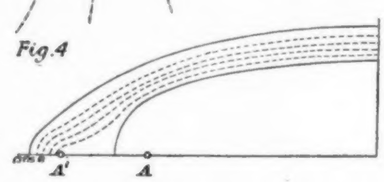
* Reproduced from *Engineering*.

current, the current flowing to the right if the point be a source, or to the left if it be a sink. Fig. 2 gives the stream-lines resultant from compounding a source with a neighboring sink in still water. Fig. 3 gives the lines resultant from compounding a source and a sink in a uniform current, or from moving a source and sink together through still water. (The resultant lines are from two finite sources and sinks, as Rankine did, or from several finite sources, as other computers did afterwards, it is equally permissible to increase the number of sources and sinks indefinitely, each source becoming correspondingly reduced in strength, until an infinite number of infinitesimal points form the basis for integration into stream-lines. In other words, the fore half by these two outlines getting into and out of phase. This, so far as the author is aware, was the first publication of any general theory of suction. Yet, it is proper to state, no further developments to which the writer has been able to carry this general theory, toward exactness in terms of particular ship-lines, have appreciably altered this first explanation, which was based upon









restricted, for clarity, to one out of the four quadrants of the figure, but they obviously exist alike in all four quadrants.) The latter condition gives us our first mathematical approximation to the displacement of water from bow to stern of a moving ship.

In Fig. 3 the stream-line A, when completed, gives the first suggestion of the water-line of a ship. If we imagine the water encompassed by this stream-line, in a sea of uniform depth equal to the draught of a ship, to be solidified without change in volume, this solid would form a ship-body having vertical sides and a rectangular cross-section; and the motion of this ship-body through the sea at the speed represented by the parallel lines of current would develop stream-lines in the surrounding sea which would be mathematically equal to those developed by the combination of moving source and sink. The source represents the water thrown off by the bow to open passage-way for the ship, while the sink represents the regathering of this water under the stern, to fill in the trough cut by the ship's passage.

The "source-and-sink" method thus opens a door to the exact analysis of the displacement of the sea by a passing vessel. It is a method to which much time has been given by many able men. Originally it was cultivated as a means for designing ships of perfect form, which should be capable of waveless progress through the water with minimum resistance, but its very limited

of the ship is represented by one (graphical) function of sources of varying strength, while the after half has a similar function of sinks. By a very ingenious method of graphical integration, without which the computation of even a few finite sources becomes intolerably burdensome, the stream-lines are deduced from these assumed functions. For the details of Taylor's method the reader is referred to his papers.[1]

Mr. Taylor made tests of the force of suction between two ship-models towed in fixed parallel position in the testing-tank at Washington, in 1909, and these were reported to the (American) Society of Naval Architects and Marine Engineers. He repeated similar tests before the British Admiralty Court sitting on the case of the "Olympic"-"Hawke" collision during the winter of 1911-1912.

The author's connection with the development of the theory of suction began in 1908, when he was called upon to explain the suction collision between the "United States" and the "Monterey," coastwise liners, in New York Bay. The trial being already under way when he was first approached, there was time only for the preparation of crude diagrams. But in connection with the "Denver"-"Lehigh" case later that same year, and in the case of the "Parima" and the "Prinzessin Irene" still later, these diagrams were got up more carefully. They discussed merely the general outline of the con-

hydraulic facts which are familiar to every pilot and ship owner.

II. Ship Waves and Sea Contours.

In all the earlier writers, and persisting in some textbooks to the present day, there is a confusion as to classification of the several sorts of ship resistance, which must be cleared before the navigator taught in those years can understand "suction" clearly. These resistances are now distinguished as (1) skin-friction, (2) wave-making, with sometimes a third, "eddy-making," which is really a part of (1). At present these resistances are mentioned only for the purpose of excluding them from the argument. Suction depends solely upon the existence, about every moving ship, of (3) the "constrained wave," which is quite distinct from the bow, stern, and echelon waves of the usual analysis of the wave-making resistance. But it was not until 1898 that there appears in the papers of the Institution of Naval Architects (British) any realization (by B. Schieldrop, of Bergen) that the "constrained wave" is distinct from these other resistances, in cause as well as in character.

The "constrained wave" of a ship is not a true wave at all. The true waves are classified as (*a*) bow waves, (*b*) stern waves, and (*c*) echelon waves. All of these are visible disturbances of the sea surface which travel away from the ship by their own inertia, when once started, and with which all seafaring people are familiar.

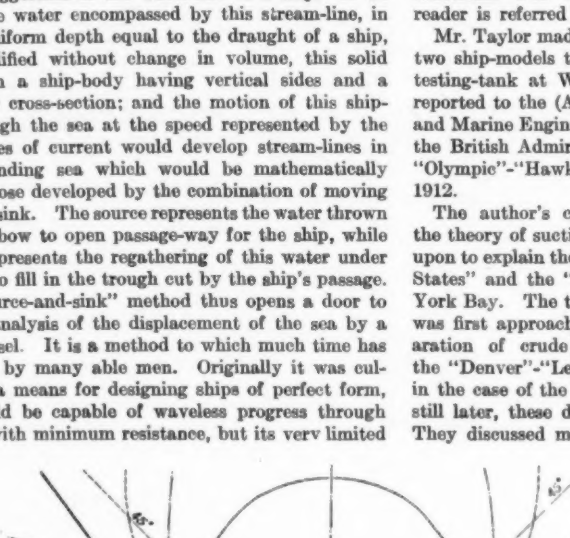


Fig. 7.

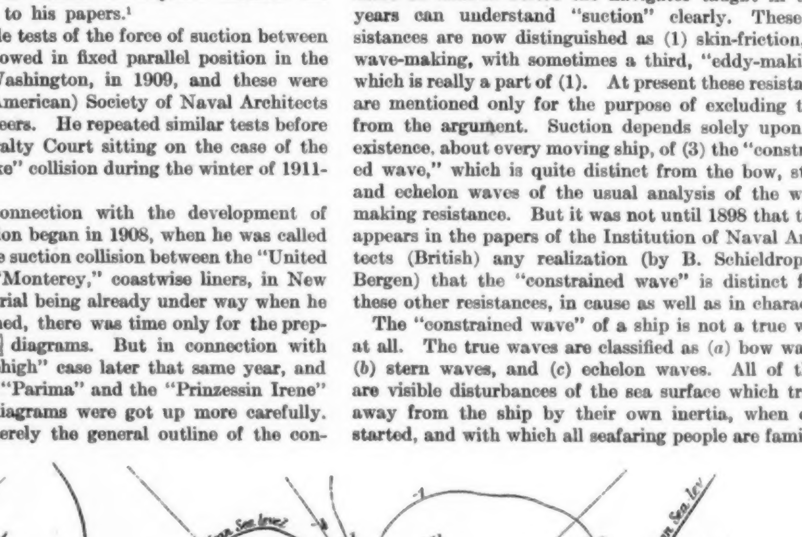


Fig. 8.

value for this purpose was realized long ago. Now the problem of "suction" offers it a new application.

By far the most ingenious and the cleverest development of the stream-line theory for actual ship-models has been contributed by United States Naval Constructor Taylor. He read two papers before the Institution of Naval Architects (British), one, in 1894, on "Two-dimension Stream-lines," and the other, on "Three-dimension Lines," in 1895. Taylor conceived the idea that if it be permissible to compound the stream-lines

strained wave, that for one ship being drawn on transparent cloth, so that it could be slid over that for the other ship, to show how suction forces were developed

[1] "On Ship-Shape Stream Forms," by D. W. Taylor. Transactions of the Institution of Naval Architects, 1894, vol. xxxv, page 385; *Engineering*, vol. lvii, page 410. "On Solid Stream Forms and the Depth of Water Necessary to Avoid Abnormal Resistance of Ships," by D. W. Taylor. Transactions of the Institution of Naval Architects, 1895, vol. xxxvi, page 234; *Engineering*, vol. lix, page 489 and 497.

The "constrained wave," on the other hand, is often invisible and usually needs to be looked for, even when visible. It consists of a wide, low mound of water which the ship piles up ahead of herself, and which accumulates until enough surplus pressure is gathered to start the water into motion aft, beneath or around the hull. Its height is very low, like a ground swell, but its bulk is tremendous. Its trough may be seen on either beam amidships, and at the stern rises a second low crest. Although it is relatively to this that the true waves

rise visibly, yet the "constrained wave" itself is visible about every fast vessel, and in tugs it often rises a fair fraction of the freeboard, the hull "squatting" visibly into its trough.

This "constrained wave" may be explained in terms of the stream-line analysis. The two-dimension streamline presupposes that the sea is of uniform depth, that the ship's sides are everywhere vertical, reaching to the sea bottom, and that the sea is covered with a thin sheet of rigid ice, strong enough to prevent any vertical alteration of sea surface. This ice may be supposed not to interfere with the motion of the ship, or the ship may be a submarine just reaching from the bottom to surface. Under such conditions alone would the motion of the water displaced by the ship's motion be purely horizontal. Under such conditions the increase in pressure necessary for accelerating the water away from the bows, and that engendered by its arrest at the stern again, would remain purely *pressure*, confined by the rigid ice against rising in surface-waves.

But in actuality there is no ice. The increase in pressure ahead of and astern of the ship actually occurs, but it is partially relieved at the sea-surface. A readier means for the release of the water than *horizontal* acceleration is *vertical* acceleration. The water gets out of the ship's way by rising vertically from either bow, in waves. The most striking instance of this is the tiny jet of water often appearing right at the stem of river steamers. This water is displaced by a hull of rectangular outline, but small dimensions (the stem), which is propelled at disproportionate speed by a relatively enormous power; hence the vertical acceleration of the water is exaggerated.

But a more common form of vertical acceleration is seen in the "bow waves," which rise on either bow, and repeat themselves in a series extending obliquely aft along lines making angles of about 23 degrees with the ship's course, ultimately merging themselves with the echelon waves. From the stern trail away two similar series of "stern waves," but much smaller than the bow waves. On either beam, and all across the wake, spreads the procession of broad, low echelon waves. All of these are due to *vertical* acceleration of the water due to the lack of constraining ice, and all of them constitute deductions of energy from the "constrained wave," which is normally due to purely horizontal acceleration of the water.

In actuality, too, there is always room for some water to escape beneath the ship's bottom, instead of spreading out laterally. In deep water this is the path for most of the displaced water. But in shallow water this path is cut off. Even where there is a foot or so of water between hull and sea-floor this space is useless for passage of water, because of the turmoil of eddies. And since the force of suction is developed only by an acceleration of water, which finds its pure and best expression only when the ship extends to the bottom, while the sea-surface is constrained by imaginary ice, these are the conditions which will be assumed throughout the discussion. All question of bow waves, echelon waves, etc., is thus eliminated.

In such a sea let there be held a vertical pole, extending to the bottom, which is then moved horizontally. This is like a vertical pipe having perforations in its sides, the side looking toward the course ahead being a "source," while the after side is a "sink." Imagine two lines drawn on the chart through the point representing such a pole, at angles of 45 degrees with its course, forming four quadrants—one ahead, one astern, and one on either beam. The theory of stream-lines shows that in the quadrants ahead and astern the sea-pressure is greater than normal, so that, if there were no ice present, the sea-surface would be elevated above normal. In the quadrants on either beam, conversely, the sea-pressure is less than normal, so that, in the absence of ice, the sea-surface would be depressed. The 45 degree lines are the loci, or contour lines, of mean sea-level.

Such a four-phased distortion of the sea-surface actually accompanies every ship. Its exact form is influenced by the ship's model and by the energy leaking away in vertical wave-forming acceleration. But, in essence, it is always there, approximating the 45-degree lines in mean sea-level contour. It is due solely to horizontal motion of the water, and it constitutes virtually the sole force causing suction.

This "constrained wave" is not properly a wave at all. It does not proceed by its own inertia, but is held constrained, as to form and magnitude, by the environing solid ship and sea-bottom. It is stationary relatively to the ship. Its inertia plays no part so long as the depth remains constant. When that varies, however, the inertia of the constrained wave becomes the most powerful force controlling the ship. For while its head is low—so low as usually to be invisible—yet the mass of water involved is enormous. It extends away from the ship indefinitely, decreasing with distance, but still perceptible at several ship-lengths away.

The form of this constrained wave is markedly distorted near the ship, away from the simple 45-degree lines of mean sea-level developed by the pole, by the lines of the ship. It will be necessary to trace further in detail these influences before the constrained waves of actual ships can be studied for suction purposes.

Every moving ship acts approximately like the vertical pole just imagined as moved horizontally through the water—viz., to distort the sea-surface about it in four quadrants, demarked by oblique 45-degree lines through its center of displacement. The quadrants ahead and astern exhibit surplus pressures, or elevations, of the surface above mean sea-level. The quadrants on either beam show deficits below mean sea-level; but in the case of the actual ship its elongated form distorts the 45-degree lines near the ship into curves of a hyperbolic form, asymptotic to the 45-degree lines, meeting the hull on either bow or either quarter.

In Fig. 5 are shown two ships in water-line plan, *A* and *B*, overlapping each other on parallel courses. The hyperbolic contours of mean sea-level are shown extending from either bow and quarter; the plus and minus signs indicate the surplus and deficit of sea pressure in the neighborhood of each ship, while the net horizontal pressure upon the hull is shown by arrows—an arrow heading toward the hull indicating surplus, and one heading outwardly a deficit, of pressure. The ships will be assumed to be moving toward the right, although the curves would be the same (in this particular case) for motion in either direction.

Without attempting now to indicate the exact form of these curves, which will be discussed later, it is plain at a glance that the two sets of plus and minus signs must cancel each other, to some degree at least. Thus ship *A* will have its lateral pressures along its starboard bow *increased* by the influence of *B's* forward quadrant of surplus pressure, while the pressures along *A's* starboard quarter will be *decreased* by the influence of *B's* port lateral deficit of pressure. Since the normal sea pressures along *A's* port side are virtually unchanged by *B's* presence, *A* will feel a tendency to swing to port.

Following the same reasoning as to the effect upon *B* of *A's* starboard and astern quadrants, it appears that *B* must feel a tendency to swing to port also. But whereas *A's* swing in response to these forces carries her away from their origin and decreases the danger of collision, except with objects on *A's* port hand, any slight response of *B* to these forces will very rapidly exaggerate them and accelerate her approach to *A's* quarter.

To the engineer, the situation may be clearer if explained in terms of the familiar Venturi meter, a diagram of which is given in Fig. 6. In the Venturi any surplus pressure existing within the conduit at either end, as indicated by the arrows, is altered more or less into a deficit at the "throat" *B* by the restricted diameter, and the consequent acceleration of the water at this point. If a branch pipe *D* be connected at this point, the deficit may be enough to draw fluid in through this pipe, although water might flow outwardly with force at *E*. Or, if the Venturi be made of flexible material, when the flow has reached a certain velocity the deficit of pressure at *B* will cause the walls to collapse; and this collapse will be sudden and violent, in unstable equilibrium.

Now the space between the two ships of Fig. 5 offers the most direct pathway for the water which, displaced by both vessels, must get from ahead to astern by some way or another. But it forms a *restricted* pathway, with gradual convergence and divergence of solid walls on either side of the "throat." In all this it is quite like a Venturi. But if ship *B* swings a bit to port it creates a situation quite like the first "give" of the throat of the flexible Venturi—the forces engender their own acceleration, in unstable equilibrium, and the motion, once started, accelerates rapidly to a sudden and violent end.

Since the situation of Fig. 5 is usually created by a larger, faster vessel overtaking a smaller, slower one, the latter finds itself first in the *A* position; but this is the position of less danger and is often passed without mishap. But when the smaller vessel has dropped back into the *B* position it is in the greatest danger. The majority of suction collisions occur in this position, the overtaken vessel suddenly swerving uncontrollably—usually in defiance of a hard-over helm, and often against reversed engines—into the quarter of the other vessel.

Usually, of course, the larger vessel is unaffected by the forces engendered mutually between the two; but sometimes it is the larger vessel which is the slower one. Indeed, the recorded instances of suction seem to include every conceivable combination of circumstances which could set these forces at work, with various results. Frequently the ship in the *A* position is driven off her course enough to collide with other vessels, or with a bank. In one instance, a large freighter going down New York Bay, when overtaken by a liner, was swung eight points off her course by this repellent component of the "suction" forces—fortunately having sea room enough to check her way before running aground—but was left in that position helpless until the liner was well by.

For it is obvious that the forces created by these "constrained" waves following and preceding the ships can easily be far greater than any of those ordinarily relied upon for maneuvering. While the altitude of the constrained wave is slight, its extent covers an area of ship-side which is enormous when compared with the rudder surface. Indeed, the difficulty in connection with suction is not to explain it, but to explain how it is that so many ships pass closely without its becoming an overwhelming factor. The most frequent answer is, *depth of water*. It requires no mathematics to show that this Venturi-like restriction of waterway between the two ships is much worse in shallow water than in deep. But suction collisions sometimes occur in water which, while not very deep, provides enough space beneath the hulls to pass a good deal of water; while in quite shallow water vessels often pass very close in safety. To answer these questions the exact form of the constrained wave needs further consideration.

(To be concluded.)

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